

THE
NEW UNIVERSAL
SINGLE MICROSCOPE,
 Invented, Made and Sold by
GEORGE ADAMS
at Tycho Brahe's Head in Fleet Street,
LONDON.

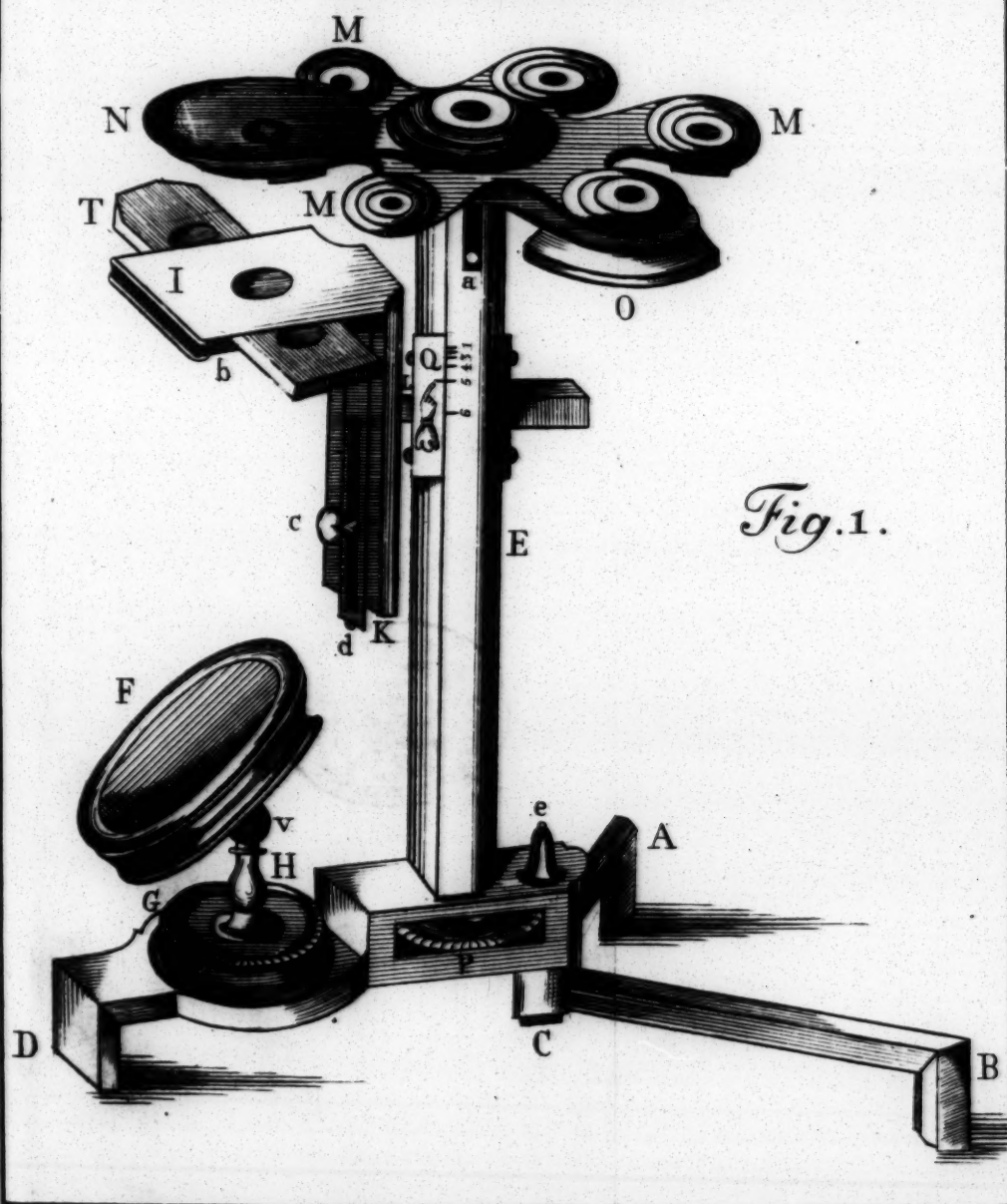


Fig. 1.

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Micrographia Illustrata,
O R,
The Knowledge of the MICROSCOPE Explain'd:
Together with an ACCOUNT of
A New Invented
UNIVERSAL, Single or Double,
M I C R O S C O P E,
Either of which is capable of being applied to an Improv'd
S O L A R A P P A R A T U S.

This TREATISE contains a Description of the Nature,
Uses, and Magnifying Powers of MICROSCOPES in general; together
with full Directions how to prepare, apply, and examine, as well as
preserve, all Sorts of minute Objects:

Also an ACCOUNT of
The principal MICROSCOPICAL DISCOVERIES, that have hitherto been
mentioned by the most celebrated A U T H O R S, together with a great Variety
of new Experiments and Observations.

The W H O L E being, as it were,
A NATURAL HISTORY of a Multitude of Aerial, Terrestrial, and
Aquatick Animals, Seeds, Plants, &c.

To which is added
A TRANSLATION of Mr. JOBLOTT's Observations on the Animalcula, that are
found in many different Sorts of Infusions;

A N D
A very particular ACCOUNT of that surprizing Phenomenon, *The Fresh Water Polype*,
translated from the *French Treatise* of Mr. Trembley.

This WORK is compiled for the Assistance of those, who are desirous of surveying the ex-
tensive Beauties of the minute Creation,

And is illustrated with 65 Copper-Plates, curiously engrav'd, which contain above 560
Pictures of MICROSCOPIC OBJECTS.

By *GEORGE ADAMS*,
Mathematical, Philosophical, and Optical Instrument-Maker, at *Tycho*
Brabe's Head, in *Fleet-Street*.

L O N D O N:
Printed for, and Sold by the A U T H O R.

MDCCXLVI.





INTRODUCTION.

THE Study of Nature, or in other Words, a serious Contemplation of the Works of God, is certainly one of the most pleasing and useful, as well as most extensive Kinds of Knowledge. It is indeed the great, and proper Object of our rational Faculties; for surely we cannot employ our Reason better, than in endeavouring to make ourselves acquainted with the glorious Works of that Being, to whose Goodness we owe it.

Natural Philosophy is now so greatly improv'd in all its several Branches, that few Persons, who have had the Happiness of a liberal Education, are wholly unacquainted with the Value of it. But still the Generality of Mankind are guilty of one very great Mistake, for they are apt to form an absolute Judgment of the Works of Nature, from outward Appearances only; and so imagine, that the most grand and magnificent Parts of the Creation, are
always

always most perfect, and for that Reason most worthy of our Regard. The Splendour of the Sun is visible to every Eye, and we need only look upwards in order to be convinced, that nothing less than infinite Power and Wisdom, could first create the Universe. What, but an Almighty Hand, could raise such a glorious Canopy as that of the Heavens, so richly adorned with Stars? Or stretch out such a spacious Area, as this terraqueous Globe on which we tread, and sail; and which is furnish'd with every Thing that is necessary for our Support or Happiness? And indeed these great Truths are so very obvious to the lowest Capacities, that few Persons pretend to dispute them; but then it must likewise be own'd, that Men are generally apt to confine their Attention to the most shining Parts of Philosophy, and so treat every Thing else with Coolness and Indifference, and even some Degree of Contempt. But surely a true Philosopher is one, who diligently pursues the Study of Nature, in all its several Branches; who can behold with Admiration her noblest Productions, and yet view with Pleasure the smallest of her Works; in short one, who thinks every thing excellent, that owes its Formation to her skilful Hand. Nor is this a forced and imaginary Description, but a real Character; and we need only take a transient View of some of those Creatures, with which all Parts of the Earth are so plentifully stored, in order to be convinced of the Justness of it. For whether we regard their Elegance, and Beauty; or consider their Fitness to answer those Purposes, for which they were designed; in both these Respects we shall find,

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find, that the smallest Creatures are perfect in their Kind, and carry about them as strong Marks of infinite Wisdom and Power, as the greatest. How many curious Animals inhabit the Air, and what Numbers traverse the deep Waters. The whole Earth is full of Life; there not being a single Tree, Plant, or Flower, but what affords Food and Shelter to a Species of Inhabitants peculiar to itself. And then if we call in the Assistance of Art, what a new Scene of Wonder opens to our View? What an infinite Variety of living Creatures present themselves to our Sight? Indeed their extream Minuteness may at first seem a just Argument for that low Opinion, which the Vulgar are apt to entertain of them; however, if we examine them with Closeness and Attention, we shall soon discover their divine Original. We shall then survey with Admiration the wonderful Art and Mechanism of their Structure; wherein such a Number of Vessels, Fluids, and Movements, are collected into a single Point; and That often invisible to the naked Eye. What a Profusion of the richest Ornaments, and gayest Colours, are frequently bestowed upon one little Insect; and yet there are Millions of others, that are as beautiful and wonderful in their Kind. Some are covered with shining Coats of Mail; others adorned with Plumes of Feathers; and all compleatly furnish'd with those Weapons, that are most proper for defending themselves, as well as attacking their Enemies. In short, the more we enquire into Nature, the more excellent she appears, and we shall constantly find, that the Beauty of her Works will gradually rise in Proportion to our Knowledge of them. There is no such Thing as Meanness in
any

any of her Productions; some indeed may be more grand, and happen to strike our Senses more strongly than others, but all are perfect in the highest Degree.

If then a serious Contemplation of the Works of God, may justly be consider'd as an excellent Kind of Knowledge, and worthy of our Pursuit; and if all those Works, though different in Degrees of Splendour, are still perfect; it is hoped, that an humble Attempt to improve, and encourage the Study of any Branch of Natural Philosophy, will not be unacceptable to the Publick. And since the Knowledge of the Microscope has always been look'd upon as no inconsiderable Branch of Natural Philosophy, and as that Part of it has more particularly fallen within the Compass of the Author's Studies, he has ventured to make it the Subject of the following Treatise; a Subject, which has so often employ'd the most learned Men, that it can hardly stand in Need of an Apology for the Choice of it.

Having said thus much with Regard to the Science, I shall now beg Leave to say something of the Instrument itself; and then make Haste to acquaint the Reader with what he is to expect in the following Sheets.

The Microscope is an Instrument so curious and entertaining, and so generally esteemed amongst the learned Part of the World, that one great Reason of its being so much disregarded by Men of Leisure and Fortune, must be owing to the Difficulty of using some of those, which have been hitherto invented. Besides, many Persons have neglected the Microscope, from an Apprehension, that a good Degree of Knowledge in Opticks would be necessary to their Understanding even the experimental Part of it; where-

as

as nothing more is really required, than good Eyes, good Glasses, and a well-constructed Instrument; with these Helps, a common Understanding, and a little Practice, will be sufficient to carry us through this Branch of Natural Philosophy.

Others, again, have consider'd the Microscope as an Instrument, which is perhaps capable of affording a little Amusement, or even raising our Wonder for a Moment, but is indeed of no real Service. However, this is an Objection that reflects more upon the Author of it, than the Instrument; and therefore does not seem to deserve the Ceremony of an Answer. Some also have laid aside the Microscope, after a little Use, merely from a Want of knowing what Objects to examine, and where to find them; as well as how to prepare and apply them.

I hope the Reader will find, that I have, in some Measure, surmounted all these Difficulties. For, first, I have given a clear and accurate Description of my new invented Universal Microscope; which comprehends all the several Uses of other Microscopes, in one Apparatus; a Circumstance that deserves a very particular Consideration. For Microscopes have been generally constructed so, as chiefly to excel in a single Instance; some having been adapted for viewing Opake, and others for Transparent Objects; but none capable of shewing both in the same exact Manner. I have therefore endeavoured to contrive my Universal Microscope so, as to render it capable of doing every Thing that can be expected from such a Kind of Instrument. I have likewise shewn how it may be applied to an improved Solar Apparatus; in which Application of it, there is a particular Contrivance

vance for confining Frogs, Mice, Bats, &c. in order to view the Circulation of the Blood in the Mesentery, and other Parts of those Animals.

Next I have proceeded to give a Description of all the different Sorts of modern Microscopes, that have been hitherto invented; so that any Gentleman, who is willing to purchase, may readily comprehend their several Uses, and by comparing them together, be enabled to form a true Judgment of their Value.

I come now to acquaint the Reader with what he is to expect in the following Sheets, and this I shall do in a very few Words.

And here I must be so ingenuous as to confess, that my Book contains rather a faithful Collection of every Thing that has hitherto been mention'd by the best Writers upon Microscopes, than Matters of my own Invention. However, I can truly say, that my sincere Endeavours have not been wanting, in order to range these Materials under their proper Heads, as well as to enlarge upon them, where it was requisite, in the most plain and intelligible Manner. I have likewise attempted a Translation of two very valuable Pieces; the one containing Mr. JOBLOT's Observations upon the Animalcula, that are found in many different Sorts of Infusions; the other Mr. TREMBLEY's Account of the fresh Water Polype, neither of which, I believe, has hitherto appeared in our Language.

As to the Copper-Plates, I have taken particular Care to have them copied from exceeding good Drawings, and then engraved in the very best Manner; and in order to prevent, as much as possible, any Inaccuracy, I always observed

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observed the following Method: When I had a Mind to make a Drawing of any Object, I placed it in my Universal Microscope, and applied it to an improved Solar Apparatus; by which Means the Object was thrown upon a large Sheet of white Paper, and magnified to a Degree, that cannot be conceived by those, who have never seen the Experiment. I then took my Pencil, and went over every Line of the Object, with all imaginable Care and Exactness, till I had finished a compleat Drawing of it; and this being fixed in the Camera Obscura, and so reduced, according to the strictest Rules of Perspective, to a Size proper for my Book, I drew from it the Pattern, which was sent to my Engravers. And indeed I have been so extreamly careful with Respect to the Copper-Plates, that no Expence has been wanting, in order to their being engraved in the very best Manner. It is for this Reason that I am obliged to raise the Price of my Book much higher, than I ever intended, or even desired; however, as it is not a Matter of Choice, but absolute Necessity, I hope the Publick will be so indulgent, as to take it into their Consideration.

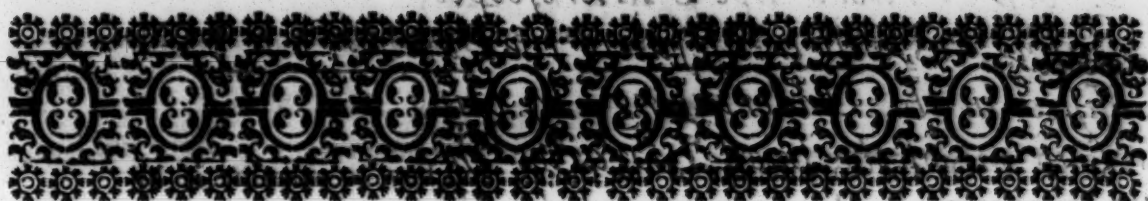
As my Microscope has had the good Fortune to meet with a favourable Reception from many Gentlemen of Distinction and Learning in ENGLAND, as well as several Parts of EUROPE; I thought an accurate Description of it would not be disagreeable to those, who had been pleased to honour me with their Custom. This was my sole Intention in sitting down to write, but I quickly found myself engaged much deeper, than at first I designed; and at length began to believe, that a Collection of the most valuable Materials that could be met with in

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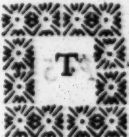
the best Writers upon Microscopes, might perhaps be pleasing, as well as useful to the Publick. I was greatly assisted in this Undertaking, by being allowed a free Access to one of the finest Libraries in ENGLAND, belonging to a noble Personage, whose Name I am not permitted to mention, but whose Goodness upon this, and all other Occasions, I shall constantly acknowledge with the highest Respect and Gratitude. I shall only add, that I have neither so much Ambition, nor Vanity, as to presume to reckon myself among the Number of those learned Men, who have wrote upon this Subject. My Profession indeed must necessarily afford me a good deal of Insight into several Branches of Natural Philosophy, and I cannot reproach myself with having wilfully neglected any Opportunity of Improvement, but still I am fully sensible, that my Book must have many Defects; however, I rely very much upon the Candour of the Reader, and so shall beg Leave, without farther Ceremony, to throw my Mite into the publick Treasury.





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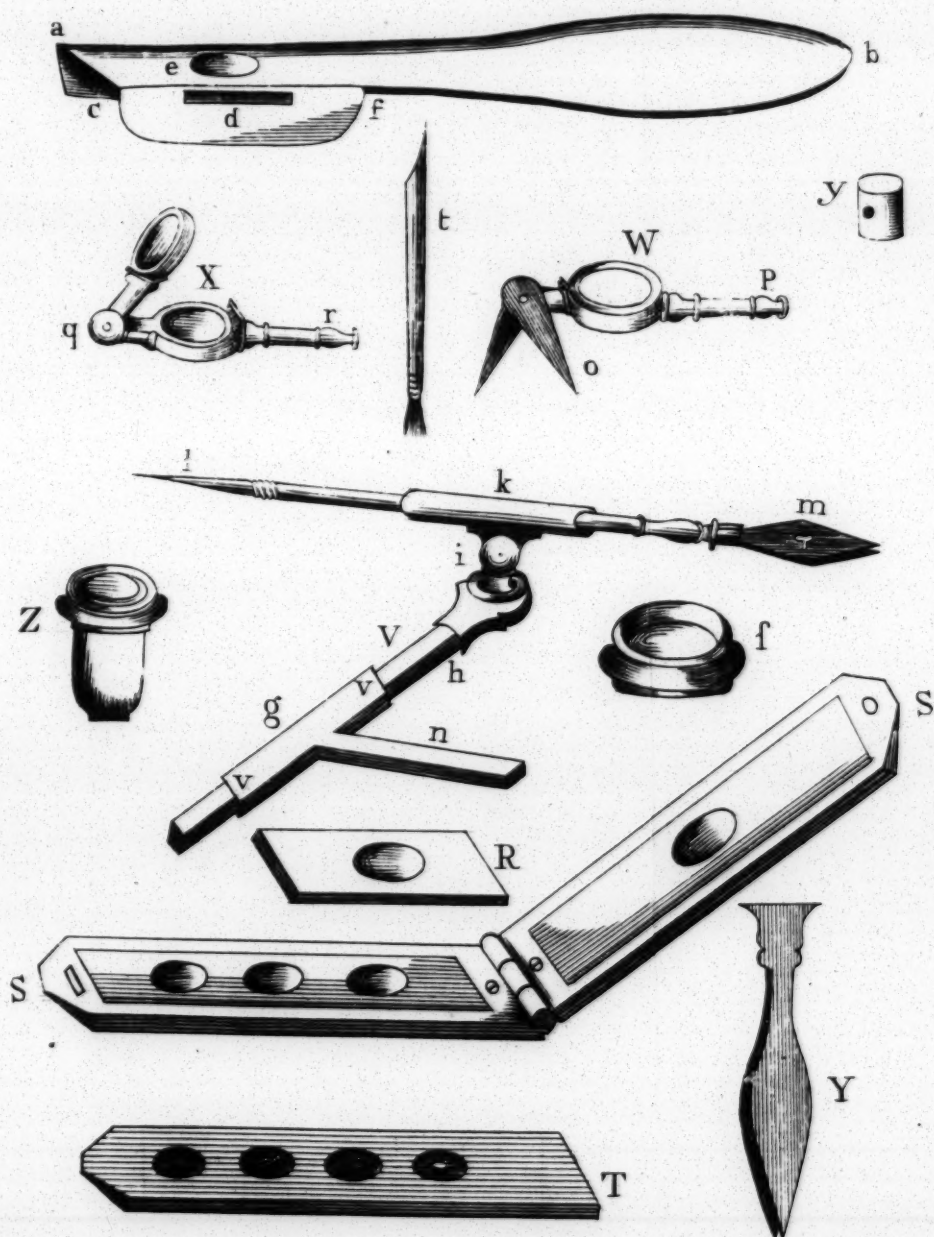


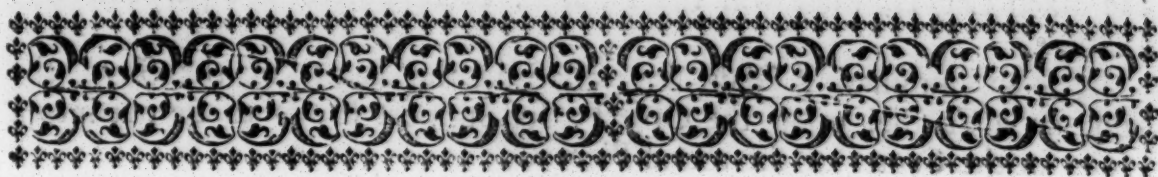
E R R A T A.

Page 98, Line 24. for *Bindings*, read *Windings*.
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Fig. 2.





C H A P. I.

Containing the Description and Use of a New Universal Single Microscope, invented, made and sold by GEORGE ADAMS, at Tycho Brahe's Head, in Fleet-Street, LONDON.



T hath long been the Desire of the Curious and Inquisitive Part of Mankind, to have a Microscope which would be Portable and Universal, that is to say, ONE ONLY *Instrument*, by which all Sorts of minute Objects might be observ'd.

I shall here present the Reader with a Description of One, which comprehends all the wish'd-for Advantages, because it contains a *sufficient (tho' small, yet all that's necessary) Apparatus*, to perform the Effects of all the various Sorts of Microscopes, (and some of them very elaborate ones too) that have been heretofore invented; nay, I can go farther, and say also of some others that have been since attempted.

It is capable of observing all those very minute Animals, which walk or crawl upon the Earth, Trees, Flowers, &c. those which fly in the Air, and the Animalcula that swim in prepared Liquors, and in those which have had no Preparation; it may also be very advantageously employed in examining the Circulation of the Blood, &c. in the Inside of larger Animals, and likewise in the Discoveries of the minute Particles of Minerals, Plants, &c. wherein may be perceived what amazing and stupendious Contrivances, exact and perfectly uniform Proportions, the great Author of Nature hath endowed those very minute Parts of the Creation with, which are so extreamly small, as to escape the best Eyes deprived of this Assistance of human Art.

This MICROSCOPE is made either of *Brass* or *Silver*, and is composed of *six* double Convex *Lens's*, of different Foci.

Represented, as put together for Use in Fig. 1.

When it is first taken out of its Box, the two Legs A, B, are to be turn'd about upon the Joint C, till they make an equilateral Triangle with

B

the

the fixed Leg D, then will the Pillar E, be supported in a perpendicular Posture.

F, is an illuminating Glass, for reflecting the Light of the Sky, the Sun, or a Candle, upon the Object: Its Support H, is to be put into a Hole, in the Center of the round Piece G.

The Object-Bearer I, with its Springs b, and Slider K, has a square Stem behind the Slider, which is to be put into a Hole at L, in the upright Pillar E.

M, M M, is a scollop'd Plate, which contains the six Magnifiers, number'd from 1 to 6, the least Number being the greatest Magnifier; in the Center, and on the Underside of this Plate, is a short Cylinder, with a small Steel Pin near the End of it. This Cylinder is to be placed in the Top of the Pillar E, in such a Manner that the aforesaid Steel Pin may go into the Slit at æ.

N, a black Eye Piece, hollowed out to defend the Eye from the Side Rays of Light, under which the Magnifiers may be turn'd round at Pleasure; so that in this Apparatus there is no Trouble in changing the Magnifiers, they being so contrived as to be successively brought under the Eye-Piece N.

O, is a reflecting Speculum of Silver, or other Metal, highly polished; which when an opaque Object is to be viewed, must be placed under the Eye-Piece N. By which Means, the Light thrown upon it from the Mirror F, will be by it collected and reflected back again upon that Surface of the Object next the Eye; which will then be so strongly illuminated, as to be examined with Ease and Pleasure.

This removes the Inconvenience of having the dark Side of an Object next the Eye, that having been hitherto an unsurmountable Obstruction to the making Observations on opaque Objects, with any considerable Degree of Exactness. For in all other modern Contrivances generally known, when a large Magnifier is used, the Nearness of the Instrument to the Object, unavoidably over shadows it so much, that its Appearance is render'd obscure and indistinct; although many Ways have been tried to throw Light upon an Object from the Sun, the Sky, or a Candle, by a Convex Lens, placed on the Side thereof, yet this refracted Light falls on the Object so obliquely, that it rather serves to give a confused Glare, than to afford a clear and perfect View.

P, is an adjusting Screw, by the turning of which an Object placed between the Object carrying Plate I, and Springs b, is readily raised or depressed; until it is brought into the exact Focus of the Magnifier.

1, 2, 3, 4, 5, 6, are Marks on the Pillar E, to shew the respective Distances of the Object from the Magnifiers, according as each Glass magnifies more or less. — For Instance, if you use the 5th Magnifier,
first

first place it under the Eye-Piece N, and then with your Finger and Thumb turn the Screw P, till the Finger of the Hand which is engraved on the Sliding-Piece Q, points to the Mark 5 on the Pillar; then will the Object be very near its exact Distance from the Magnifier; so that by a Turn or two of the Screw P, either backwards or forwards, to be found by Trial, you may soon fit it exactly to your Eye.

The Object carrying Plate I, and Steel Springs b, are capable of holding Ivory Sliders; or other Contrivances of different Thicknesses, by unscrewing the little Screw c, and with your Nail pressing down the Slider K, by the Button d, the Steel Springs will then be so separated from the Plate I, as to receive any other Part of the Apparatus; and may be there made fast by tightening the Screw c.

e, A Nut, by the screwing of which, the Joint C may be tightned, if at any Time it should wear easy.

The Plate numbered Fig. 2. represents the Apparatus belonging to the Universal Single Microscope, Fig. 1. and also to the Universal Double Microscope, represented by Fig. 3. Whereof,

a, b, f, Is a Contrivance to confine a small Fish, by putting its Tail under a Spring on the Inside at c, and tying the Body of the Fish to the long Part b, f, the two extreme Ends of the Tail, may be drawn through the Slits d, d, on each Side, that the Middle of the Tail may lie flat: Then put the End æ of this Fish-pan between the Object carrying Plate I, and Springs b, of Fig. 1, or Fig. 3, (they being first opened to a proper Thickness to receive it,) in such a Manner, that the Hole e, under which the Tail of the Fish is placed, may lie nearly under the Center of the Hole f, in the Object carrying Plate I. In this Position, the Magnifiers may be all successively turned over the Object: And the Circulation of the Blood examined from the least to the greatest Magnifier, with Ease and Pleasure. It may also be seen in the Webb between the Toes of a Frog's hind Foot, which is to be placed under the Spring at c, and its Body tied with a Tape to the Part b, f.

R, is a Piece of Glass to be placed as Occasion requires, either upon the Surface of the Object carrying Plate I, or between it and the Springs b; its Use is to hold any accidental Object that may offer; such as the Animalcules in Fluids, (which may be very commodiously examined in this Manner) Dusts, Crystals of Salts, the Farina of Vegetables, &c.

S, S, A jointed Slider, containing two flat Glasses, with Cavities sunk in them, designed for confining any small Object without crushing or destroying it; such as Aquatics, or any other live Insects, as Fleas, Buggs, Lice, &c. and is also to be placed between the Object carrying Plate I, and Springs b, which must be set wider to receive it as before directed.

T, is an Ivory Slider with four Holes, wherein to place different Objects between two Pieces of Muscovy Talcs, and is also to be applied between

the Object carrying Plate I, and Springs b, see Fig. 1, with the Ivory Slider T, applied to it.

V with its Socket g, sliding Steel Bar h, Joint i, and its springing Tube k, through which runs a Steel Wire; one End whereof terminates in a sharp Point l, and the other hath a Pair of Pliers m, soldered to it: The Joint i having a twofold Motion for the readily placing the Parts of an opake Object before the Magnifier.

The Point or Pliers, are to be thrust into, or take up, and hold any Infect or Object; either of them may be turned under the Magnifier, as best suits the Purpose.

When this Apparatus is used, the square Stem n, of the Socket g, must be put on to the Pillar E, at the Hole L, Fig. 1, and 3, (the Object Plate I, with its Springs b and Slider K being first removed,) it is represented as applied to the Microscope at Figure 3.

W is a round Object Plate, one Side black and the other white, for rendring Objects the more visible, by placing them if black upon the white, and if white upon the black Side. A Steel Spring o turns on each Side to make any Object fast, and a hollow Pipe p issues from the Object Plate which may be screw'd upon the sliding Wier's Point l. y is another black and white Object-Plate, to be stuck on the aforefaid Wires Point for opake Objects.

X is a small Brass Box, with a Joint at q and a Glass on each Side, its Use is to confine any living opake Object for Examination. This Box also hath a Pipe r, to screw over the End of the sliding Wire l.

Y, a Pair of Pliers or Forceps, to take up any Object, and manage it with Conveniency.

Z, a small Ivory Box, with Isinglass, to be placed when wanted, in any of the Ivory Sliders.

f, Is a seventh Magnifier, set in Ivory, to be held in the Hand or laid in the black Eye-piece N, for viewing any large Object.

t, A little Hair-Brush or Pencil, wherewith to wipe any Dust from off the Glasses, or to take up any small Drop of Liquid one would examine, and to put it upon the Glass R.

When a transparent Object is to be examined, thrust the Ivory Slider which contains the Objects, between the Object carrying Plate I, and the Steel Springs (they being first opened to receive the Thickness of the Slider) and observe always to put that Side of the Slider where the Brass Rings are, farthest from your Eye: Then turn the Magnifier you intend to use under the Eye-piece N, and set the Finger of the Hand on the sliding Piece Q, to the Mark answering the Number of the Magnifier.

The Microscope being placed on a Table near the Window, direct the Mirrour F towards the Sky, and then looking through the Eye-piece N upon the Object, placed next under the Plate I, turn the illuminating Glass

Single Microscope.

5

F, so about upon its Support H, and Joint v, till the Light is reflected upwards to the Object.

If it should then happen not to be at its due Distance from the Magnifier, turn the Screw P at the same Time you are looking at the Object, till it be made to fit your Eye; which you will then know by its appearing perfectly distinct and clear.

I must here observe that the Screw P is to be turned as your Hands and Arms are resting upon the Table, which is a Conveniency to be met with in no other Microscope. All others requiring the Observer to raise his Body and Arms in adjusting the Object to fit his Sight; which is not only very troublesome but tiresome too; especially if it requires any considerable Attention. Whereas in this new universal Microscope a leaning Posture is sufficient, and consequently the easiest of all others for microscopick Observations.

When an opaque Object is to be view'd, place the reflecting Speculum O exactly under the Eye-piece N; Fig. 1, and fix your Object either on the Point of the Sliding Wire l, in the Pliers m, in the Brass hollow Box X, or on the Object Plate W, as may be most convenient according to the Nature of it; then apply this whole Apparatus mark'd V, to the Microscope, by putting its Stem n into the Hole L of the Pillar E: The Object carrying Plate being first removed. See Fig. 3. where this Apparatus is applied to the Microscope. The Microscope being placed upon a Table near the Window, direct the illuminating Glass to the Light, so as to throw it upon the Speculum O, then looking through the Eye-Piece N, and that Magnifier you judge fittest for the Object you would examine; by the Assistance of the Steel Bar h, sliding in its Socket g, the Point and Pliers sliding in their springing Socket k, together with the double Motion of the Joint i. The Object may be turn'd about, rais'd or depress'd, brought nearer to the Magnifier, or put farther from it, till you hit the true focal Distance, and the Light be reflected strongly on the Object from the Speculum O. The Screw P, will also greatly assist in adjusting the Object to fit your Sight. In this Manner an opaque Object will be shewn surprisingly distinct and clear.

It is always best to view an Object at first with one of the least Magnifiers, by which Means, you may examine the whole, or a large Part thereof at once, and then gradually to inspect the several particular Parts, by successively turning the larger Magnifiers, under the Eye-Piece N, and thereby gain a true Idea of the Whole and all its Parts. Altho' the greatest Magnifiers can shew but a very small Portion of an Object at once: Yet by gently moving the Slider that contains the Object, and sometimes gently turning the Magnifier backwards or forwards within the Limits of the Hole in the Eye-Piece N, or if it be an opaque Object by sliding the Steel Bar h backwards or forwards in its Socket g, the Eye will regularly

larly survey it all: And if any Part should be out of Distance, it may be easily rectified by turning the Screw P, one Way or the other.

In using the first Magnifier in the Single Microscope, the Object is requir'd to be brought so near the Glass, as almost to touch it; therefore particular Care must be taken not to scratch it by rubbing the Slider, &c. against it; a few Turns of the Screw P will easily prevent it, and give it Room.

The Objects may be changed in the Sliders for any other you think proper, by taking out the Brass Rings which keep in the Glasses where the Objects lie, with the Point of a Penknife; and if you turn the Slider, the Talcs will fall out: After which you may put what you please between them, and replace the Rings.

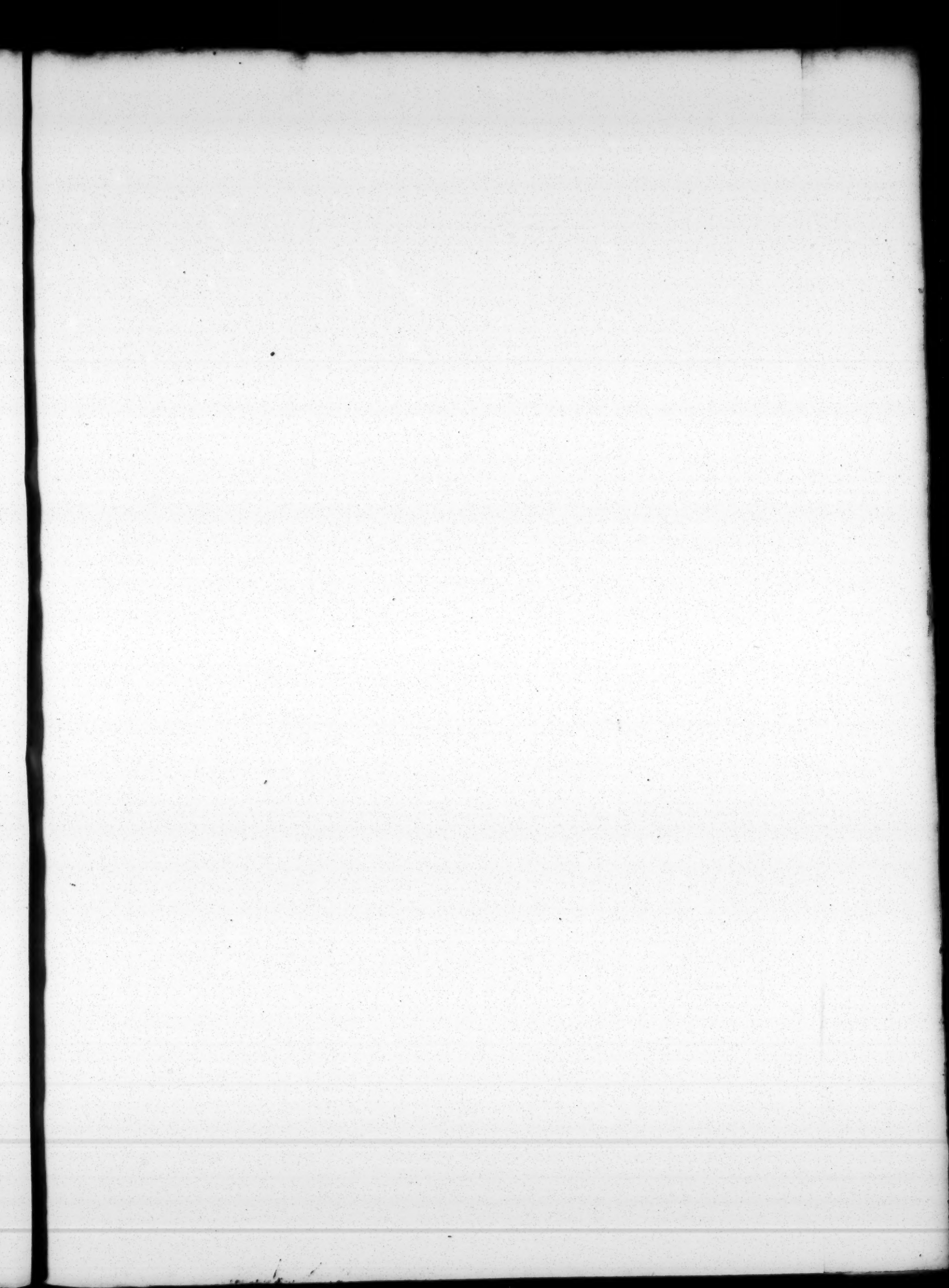
C H A P. II.

Containing the Description and Use of a New Universal Double Microscope, invented and made by
GEORGE ADAMS, at Tycho Brahe's Head, in
Fleet-Street, LONDON.

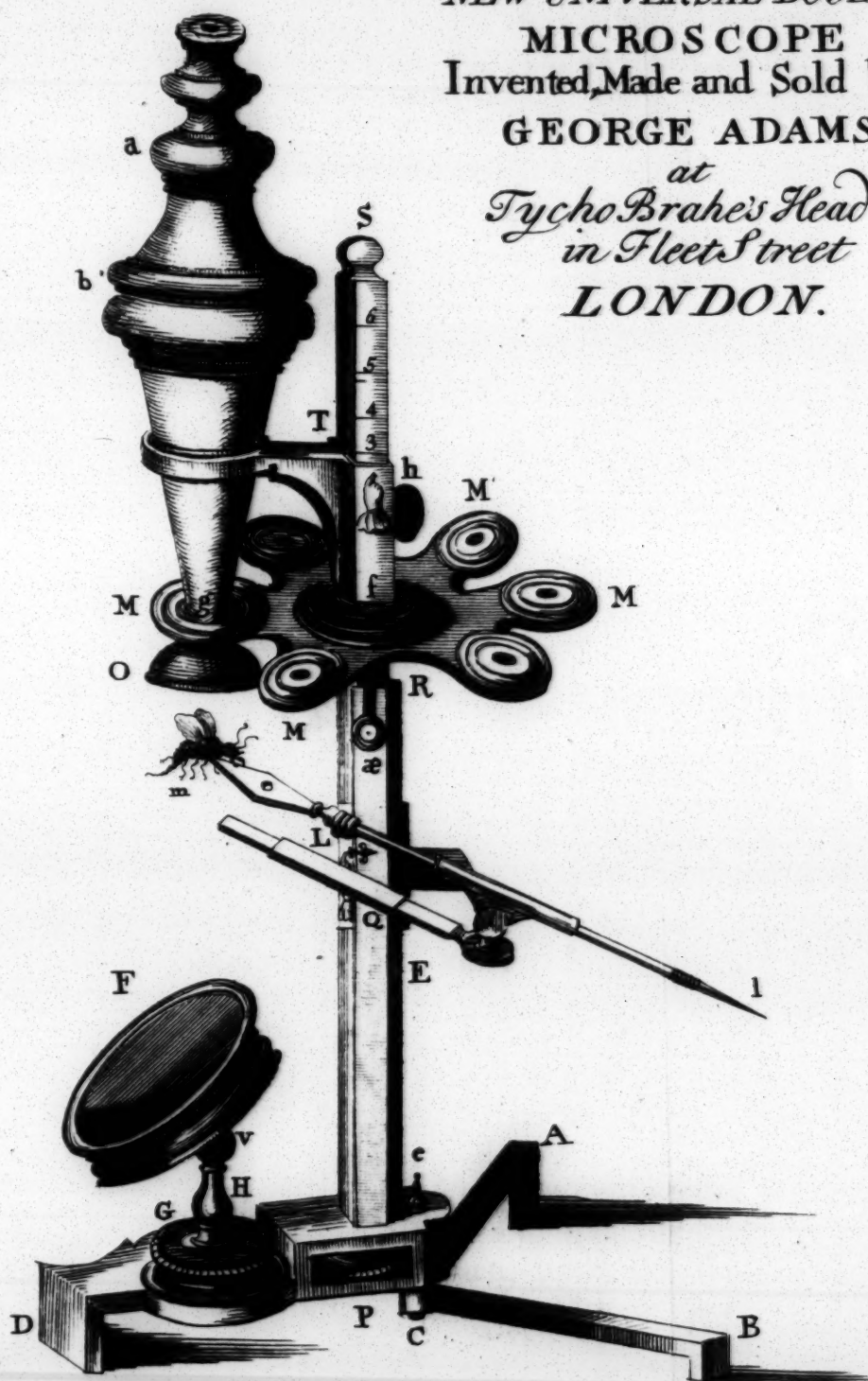
THIS Microscope is composed of three double convex Lens's, two of which are placed in the Body thereof at a and b, and the Magnifier at g, six of which belong to this Microscope, and are fixed in a scollop'd Plate M, M, M, moveable about a Center at f, by which Means either of them may be readily turn'd under the other two Glasses, as at g, whereby the Trouble of searching out for different Magnifiers is remov'd.

The Body of the Microscope is supported by the Arm T, having a circular Collar, whereinto it may be screwed, or from whence it may be easily taken; this Arm proceeds from the upper Part of the sliding Socket T, f.

The aforesaid Socket T, f, together with the scollop'd Plate M M M, and the Body of the Microscope; may be moved up or down the square Bar R S, which is divided into as many Parts (1, 2, 3, 4, 5, 6.) as there are Magnifiers of different Foci; so that the Distance of the Object from the Object-Glass may be found without any Trouble, by setting the Finger of the Hand engrav'd upon the Socket, to the correspondent Number of the Magnifier (then, under the Body of the Microscope) on the Bar R S, and fixing it there by Help of the Screw b. But as it is scarce exactly enough determined this Way, the Object may be brought nearer to, or removed farther from the Magnifier at Discretion, by a Turn or two of the Screw P. Remembering at the same Time, the upper Hand is set to any
Number



THE
NEW UNIVERSAL DOUBLE
MICROSCOPE
Invented, Made and Sold by
GEORGE ADAMS
at
Tycho Brahe's Head
in Fleet Street
LONDON.



Number on the square Bar, to place the Index on the Piece Q, to the Flower-de-luce on the upright Pillar E.

O, is a reflecting Speculum highly polished, which must be placed at R, when an opaque Object is to be viewed, on which a direct Light becomes reflected from the aforesaid Speculum.

The square Bar R S, fits into the Top of the upright Pillar E, and may be made fast thereto by the Screw at æ.

The Object-Bearer I, Ivory Slider, illuminating Glass F, with its Support H, and round Piece G, and the Apparatus V, with its Nippers and sliding Wire, &c. having been sufficiently described in the foregoing Chapter, I shall refer the Reader to that for the Uses thereof, and also for a Description of the Apparatus, which is exactly the same as that represented in Fig. 2. and its Uses and Application to this Universal Double Microscope, the very same as in the foregoing Universal Single One.

I have also adapted to either of these two New Microscopes, a particular Apparatus for confining Frogs, Mice, Bats, &c. in order for viewing the Circulation of the Blood in the Mesentery, or any of the transparent Skins, which will by and by be fully described.

It remains therefore only to shew how these two New Microscopes are best illuminated by Candle-Light, which is by letting the Rays of Light transmitted from the Candle, first pass through a Glass Globe *, filled with Water before they fall on the illuminating Glass F, and if that should prove too glaring, as it sometimes does, interpose between the Globe and Microscope, a Piece of thin oil'd Paper, by which Means most Sorts of Objects may be view'd as well by Night, as in the Day-Time.

Either of the foregoing new invented Universal Microscopes, may be applied to the solar Apparatus, and may be had at my Shop separate or together. They are very portable, and neatly packed up in small Cases.

After having given a Description of the new invented Universal Microscope, in both its Forms, that is to say, either single or double; it is convenient to say something concerning the Uses thereof. And here I must inform the Reader, that my Curiosity and Desire of rendering this Instrument as perfect as possible, hath engaged me to find out Methods, which might fully satisfy those who are willing and desirous of prying into the minute Re-cesses of Nature, and repeat the Experiments and Observations related in the following Natural History.

In order therefore to observe Flies, and other Insects of the like Bulk, stick them upon the sliding Wires Point, or pinch some Part of them between the Nippers, and apply them under the reflecting Speculum O.

I have already shewn that Lice, Fleas, Ants, and other Animals of the same Size may be observed alive, by being confined between the two

* For the Want of a Jeweller's Globe, a common globular Decanter, filled with clear Water, will answer the same End.

Glasses S, S, Fig. 2. They may also be pinch'd by the Breach between the Nippers m of the Apparatus V, Fig. 2. by which Means you will have the Pleasure of observing all the external Parts of their Bodies, and may sometimes see other Animals running too and fro upon them, which feed on and torment them; these are called Lice of the Louse, and Fleas of the Flea. They may also be placed between two *Muscovy* Talcs, as at T, Fig. 2. in an Ivory Slider.

Mites of Cheese, and their Eggs, Lice of Birds, and the Insects which infest Pears, Apples, &c. may be fixed upon the black and white Object-Plate, with a little Gum-Water, if they are opaque, or if transparent, they may be stuck to the Object-carrying Glass R, Fig. 2. with Gum Water; by which Means you may examine them with the greatest Magnifier, and with Satisfaction and Delight view their internal Structure and the Peristaltick Motion of their Bowels, &c.

All the other Sorts of little crawling Animals, which are so very small that one can hardly touch them without destroying their Lives, are best glewed as it were upon the Point of a fine sewing Needle, dipped in Turpentine. (The Needle being first made fast to the End of a short Bit of Stick by Way of Handle to it) If you do but just touch the Back or Side of any one of these minute Animals therewith, it will stick so fast thereto, as not to be able to remove itself; by which Means they may be examined with Ease and Pleasure. The sewing Needle must be held between the Nippers m, of the Apparatus V, Fig. 2. and so placed before the Magnifier, either of Fig. 1, or 3. any Part of the Animal may be turn'd before the microscopick Lens, by twisting the Handle of the sewing Needle, as you find Occasion.

Hairs, Wings of Flies, small Feathers of Birds, &c. are best perceived, and easiest examined, when placed between two *Muscovy* Talcs, in an Ivory Slider.

All Sorts of inanimate Objects, such as Grains of Sand, Seeds of Plants, Farina of Flowers, &c. may be commodiously examined, upon the Object-carrying Glass R, Fig. 2. if they are transparent; or if they are opaque, strew them lightly on one of the black and white Object Plates W or y, and apply them to the Microscope, under the reflecting Speculum o.

To preserve any of these transparent Objects, place them in an Ivory Slider, between two *Muscovy* Talcs, and the opaque ones being thinly strewed upon some of those Holly Slips of different Colours (hereafter described in Chap. 10.) the Slips being first wetted with Gum-Water.

In the Manner last mentioned, Objects of a larger Size may be preserved, such as the Heads and scaly Wings, &c. of curiously colour'd Flies, and may be conveniently placed before the Microscope, by pinching the End, or any other Part of the Slip between the Nippers m, of the Apparatus V, Fig. 2.

To examine the Animalcula in Fluids, thrust the Point of an Hair Pencil,

Fig. 4.

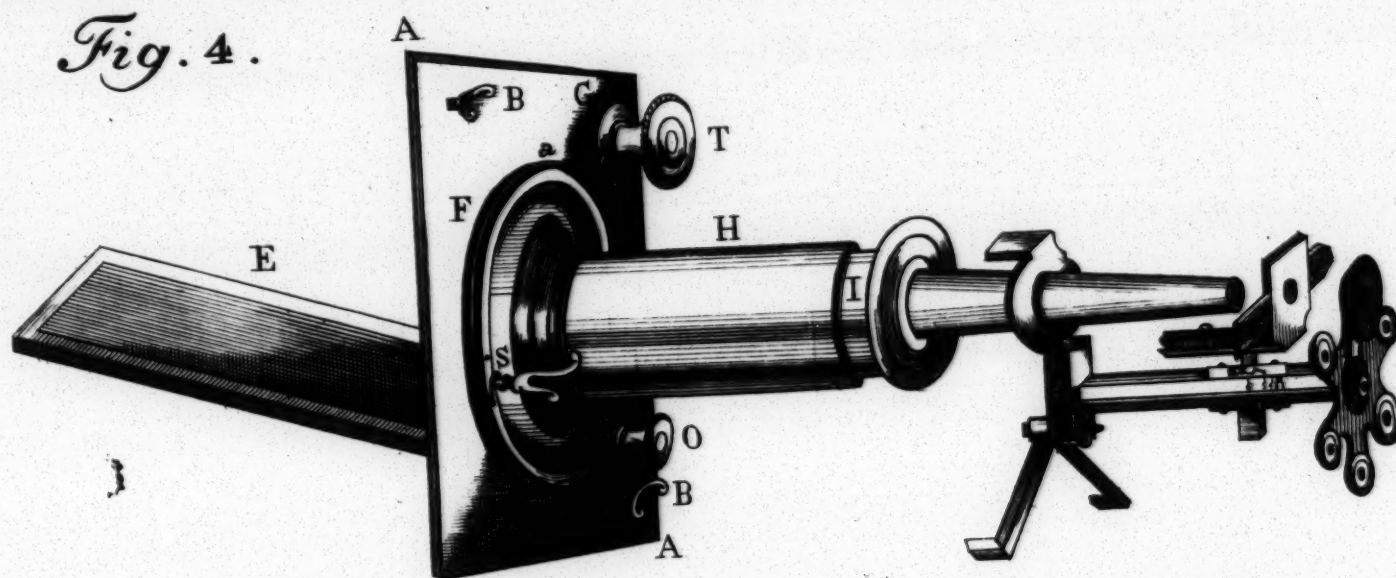
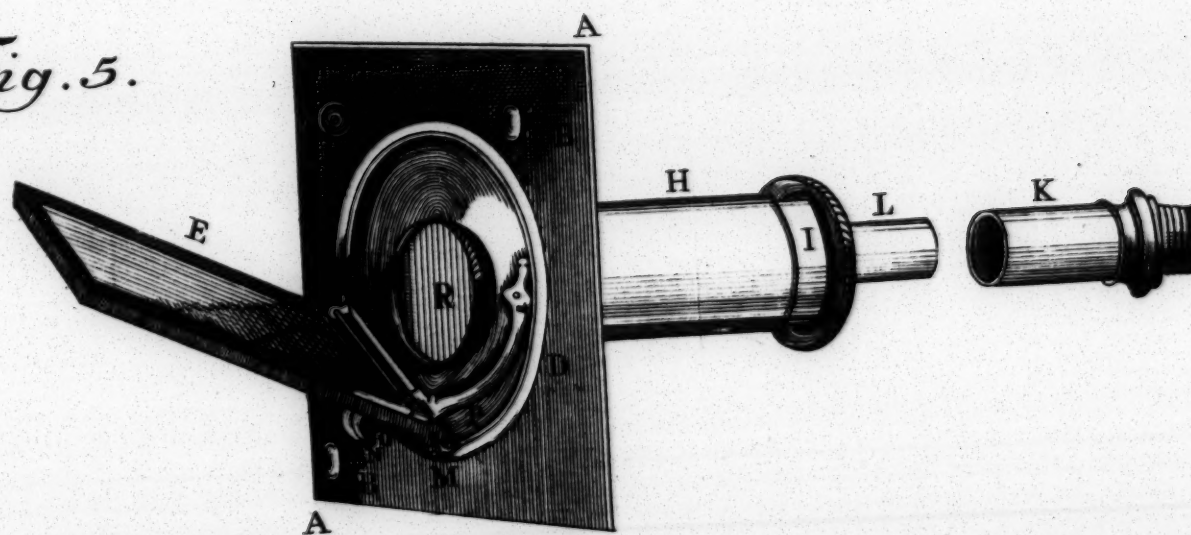


Fig. 5.



Double Microscope.

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cil, or rather the Point of a Pin about one Tenth of an Inch under the Surface of the Liquor, and near the Sides of the Vessel, that a little of it may be taken up and placed in the Hollow of the Object-carrying Glass R, Fig. 2. which should be no more than to form a Drop about $\frac{1}{16}$ of an Inch in Diameter, and that will be a Kind of Lake or Pond, in which you may discover a surprizing Quantity of extremely minute fish-like Animalcula of different Sizes, Figures, and Motions.

I have already shewn how to apply the Tail of a small Fish, and the Foot of a Frog, to the Fish-Pan a, b, f, Fig. 2. in order to shew the Circulation of the Blood. And shall by and by explain another Method which I have contrived, for viewing the Circulation of that Purple Tide in Animals of a larger Size.

The Ease and Readiness with which every minute Object may be applied to this Instrument, hath render'd it the most universal and commodious of any other of the present Sorts, for by this one Instrument, all the particular Uses of every other Sort are obtained with less Trouble, and consequently more Satisfaction to the Observer.

C H A P. III.

Of the Improved Solar, or Camera Obscura Microscope.

THIS most surprizing Contrivance, is compos'd of a Looking-Glass, a Tube, and the *Universal Microscope*, Fig. 1, or 3, and as it depends entirely on the Sun-shine, is to be used in a Chamber, from whence all the Light must be excluded, except what passes through the aforesaid Tube.—A Picture of the whole Apparatus put together, is shewn Fig. 4. and the other Side of the Solar Apparatus by itself, Fig. 5.

Whereof A, A, in both the Figures, is a square Brass Plate, thro' which two Screws B, B, pass; their Screw-Nuts are seen at B, B, Fig. 4. and the Head of their Screw Pins at B, B, Fig. 5. A large Hole, $4\frac{3}{4}$ Inches Diameter, must be cut in the Window-Shutter, which is somewhat bigger than the Circle D D, Fig. 5. And then applying the square Plate thereto, bore thro' it two other small Holes, answerable to those in the Plate at B and B. Put the Screw-Pins thro' these last made Holes in the Shutter, and with their Nuts, screw the square Plate fast thereto, the Looking-Glass being without the Window.

In the Middle of the square Plate A A, is made a circular Hole to receive the flat Brass Ring D, D, on one Side, and on the other Side a narrower Ring F, whose Edge, which projects a little beyond the Hole, is turn'd

C

into

into a shallow Groove a a, wherein runs a filken Line, which by twisting round, and then crossing over a Brass Pulley G, performs an easy Motion for turning round the flat Wheel D, D, and all the Parts thereto affixed.

H, is a Brass Tube, that screws into the Middle of the two Brass Rings D D, and F, and becomes a Case for the lesser Brass Tube I, to be drawn backwards or forwards in.

K, is a short Tube of Brass, which fits into the Foot D of the Universal Microscope, Fig. 1, or 3. the illuminating Glass F, and the round Piece G, being first taken out to make Room for its Reception. The Tube K, fits over another short Tube L, which is solder'd to the End of the inner Tube I, and is distinctly seen in Fig. 5.

E, is a Looking-Glass of an oblong Figure, set in a Frame of polished Brass, and fixed to the broad Ring D, D, Fig. 5. by Means of a long Steel Screw M, going through a Joint at the Bottom of the Frame, and may be screw'd in, or taken out at Pleasure. At the Bottom of the Looking-Glass Frame, is fixed a circular Piece of Brass N, against which the End of the Screw O presses, in order by screwing it to elevate the Glass, which is depressed on its being discharged; by the Force of a strong Spring P, acting against a Bracket, fixed to the Side of the Looking-Glass Frame.

R, a convex Lens, whose Focus is about 12 Inches, fixed at the outward End of the Tube H, to collect the Sun's Rays, and throw them strongly upon the Object.

S, Fig. 4. is a Steel Pin, having one End of the silk String fastened to it, by the Turning of which, the String may be tightened, if at any Time it should be too slack; the other Extremity of its being tied by a Knot to the Ring F.

When this Microscope is used, the Room must be made as dark as possible; for on the Darkness of the Room, and the Brightness of the Sun-shine, you are to expect a perfectly clear and distinct Image.

The Looking-Glass being put thro' the Hole in the Window-Shutter, and the square Plate A, A, fasten'd thereto by its Screw Pins C, C, and Nuts B, B, as before directed. Screw the Tube H into the Middle of the Plate and Rings, and the double convex Lens R on its Outside. Then adjust your Looking-Glass to the Altitude and Situation of the Sun, by Means of the Screw O, and the Silk-Line with its Pullies F and G, the first of these raises or depresses the Looking-Glass, and the latter by turning the Boss T, inclines it to either Side; by which compound Motion, the Glass is so readily managed, as to be brought into a right Direction for throwing the Sun's Rays thro' the double convex Glass R, and Tube H, upon a Paper-Screen, placed about 5 or 6 Foot Distance from it; and

Camera Obscura Microscope.

II

to form thereon a round Spot of Light, which is a Proof of your Glass being rightly adjusted ; but this must not always be expected, for the Sun is so low in Winter, that if it shines in a direct Line against the Window, it cannot then afford a perfectly round Spot of Light, but if it be on either Side of you, it may be obtained even when the Sun is in the southern Tropick.

Being thus far prepared, screw the Tube K into the Foot D of the *Universal Microscope*, Fig. 1. or Fig. 3. and slip it over the small End L of the inner Tube I, (all which is represented as done and ready for Use in Fig. 4.) and pull out the said Tube I, more or less, as the Object is capable of sustaining the Sun's Heat. Dead Objects may be placed within about an Inch of the Focus of the double convex Lens R, which Distance must be shortened for living Creatures, or they will soon be killed.

If the Light falls not exactly right, you may readily direct it thro' the Axis of the Microscopick Lens; and there keep it during the Time of your Examination, by the Help of the Screw O, and Boss T, following the Sun's Motion.

The Objects are to be managed and brought to their true focal Distance, by observing the Directions given in Chap. I. in the Description of the *Universal Microscope*, Fig. 1, that is, they may be placed between the Object-carrying Plate I, and Springs b, stuck upon the Point, or held in the Nippers, and adjusted to their exact Focus, by the Screw P, &c.

The most useful Magnifiers in the solar Microscope, are the 4th, 5th, or 6th.

Having taken Notice of a Screen to throw the Images of Objects upon ; such a Screen is usually made of a Sheet of the largest Elephant Paper, strain'd on a Frame, which slides up and down on a round mahogany Pillar, in the Manner of some Fire Screens. A larger Sort are composed of several Sheets of the same Paper pasted together on Cloth, and let down with a Roller from the Ceiling in the Manner of a large Map.

There are many Conveniencies in this, which no other Microscope has, for as it shews Objects larger than any other Way, there is Reason to hope that further Discoveries will be made by it. Besides this particular Property it hath, that Numbers of People may view an Object at the same Time, and may point to the different Parts thereof, and by discoursing on what they see, may understand each other better, and more probably find out the Truth, than when they are obliged to look one after another. Besides the weakest Eyes may use it without the least Straining or Fatigue. By this Means also, an Object may be outlined exactly, and thereby a Drawing of whatever is curious be easily obtained.

C H A P. IV.

The Description of the Screw-Barrel, or Mr. WILSON'S Single Pocket Microscope.

THIS Microscope of Mr. *Wilson's*, is an Invention of many Years standing, and was in some Measure laid aside, till Dr. *Liberkun* introduced the solar Apparatus, to which he applied it, there being no other Instrument at that Time would answer his Purpose so well; since which Time it has been revived, and esteemed the best, tho' very troublesome in most Cases.

The Body of the Microscope is represented by A B, A B, Fig. 6. made either of Silver, Brass, or Ivory.

C C, is a long fine threaded Male Screw, that turns into the Body of the Microscope.

D, a convex Glass, at the End of the said Screw; on which may be placed, as Occasion requires, one of the two concave Pieces of thin Brass, with Holes of different Diameters in the Center of them, to cover the said Glass, and thereby diminish the Aperture, when the greatest Magnifiers are used.

E, three thin Plates of Brass, within the Body of the Microscope, one whereof is bent semicircularly in the Middle, so as to form an arched Cavity for the Reception of a Tube of Glass.

F, a Piece of Wood or Brass, arched in the Manner of the said Plate, and fastened thereto.

G, The other End of the Microscope, where a hollow Female Screw is adapted to receive the different Magnifiers.

H, a spiral Spring of Steel between the said End G, and the Plates of Brass E, intended to keep the Plates in a due Position, and counter act against the long Screw C.

I, a small turn'd Handle for the better holding the Instrument, to screw on and off at Pleasure.

To this Microscope belong seven different magnifying Glasses, six of which are set either in Silver, Brass, or Ivory, as in the Figure K, and are marked 1, 2, 3, 4, 5, 6. Observe the lowest Numbers are the greatest Magnifiers.

L, is the seventh Magnifier, set in the Manner of a little Barrel, to be held in the Hand for viewing any larger Object.

M, is a flat Slip of Ivory, called a Slider, with four round Holes thro' it, wherein to place Objects between two *Muscovy* Talcs.

Single Pocket Microscope.

I 3

Six such Ivory Sliders, and one of Brass, are usually sold with this Microscope, some with Objects placed in them, and others empty, for viewing any Thing that may offer, but whoever pleases to make a large Collection of Objects, may have as many as he desires.

There is also a Brass Slider, not expressed in the Figure, to confine any small Object, that it may be viewed without crushing or destroying it.

N, is a Forceps, or Pair of Pliers, for the taking up of Insects, or other Objects, and adjusting them in the Glasses.

O, a little Hair Brush or Pencil, wherewith to take up and examine a small Drop of Liquid.

P, is a Tube of Glass, to confine living Objects, such as Frogs, Fishes, &c. in order to discover the Circulation of the Blood.

When you would view an Object, thrust the Ivory Slider in which the said Object is placed, between the two flat Brass Plates; observing always to put that Side of the Slider where the Brass Rings are farthest from the Eye. Then screw in the magnifying Glass you intend to use, at the End of the Instrument G, and looking through it against the Light, turn the long Screw C C, till your Object is brought to the true focal Distance, which you will know by its then appearing perfectly clear and distinct. The Way of examining any Object accurately, is to look at it first thro' a Magnifier, that will shew the whole thereof at once, and afterwards to inspect the several Parts more particularly with one of the greatest Magnifiers; for thus you will gain a true Idea of the Whole, and all its Parts. And tho' the greatest Magnifiers can shew but a minute Portion of any Object at once, such as the Claw of a Flea, the Horn of a Louse, or the like; yet by gently moving the Slider that contains your Object, the Eye will gradually overlook it all; and if any Part should be out of Distance, the Screw C C will easily bring it to the true Focus.

As Objects must be brought very near the Glasses, when the greatest Magnifiers are used, be particularly careful not to scratch them, by rubbing the Slider against them, as you move it in or out. A few Turns of the Screw C C, will easily prevent this Mischief, by giving it Room enough.

How to change the Objects in the Ivory Sliders, has been shewn in the first Chapter.

The Circulation of the Blood may be easiest seen in the Tails or Fins of Fishes, in the thin Membrane between the Toes of a Frog's hind Foot, or best of all in the Tail of a Water-Newt. If your Object be a small Fish, place it within the Tube, and spread its Tail or Fin against the Side thereof: If a Frog, chuse such an one as can but just be got into your Tube, and with a Pen or Stick, expand the transparent Membrane between the Toes of its hind Foot, as wide as you are able. When your Object is so adjusted,

ed, that no Part thereof can intercept the Light from the Place you intend to view, unscrew the long Screw C C, and thrust your Tube into the arched Cavity quite thro' the Body of the Microscope; then screw it to the true focal Distance, and you'll see the Blood passing along its Vessels with a rapid Motion.

Make Use of the third and fourth Magnifiers for Frogs, or Fishes; but for the Tails of Water-Newts, the fifth or sixth will do; the first or second Magnifier cannot well be employed to this Purpose, for the Thickness of the Tube, wherein the Object is placed, will scarce admit its being brought so near to the focal Distance of the Magnifier.

This Single Microscope of Mr. *Wilson's*, has sometimes been formed into a double one, by screwing it to a Tube, with an Eye-Glass at the End thereof, it is also made to answer nearly the Purposes of the large double reflecting Microscope, by the Addition of the following Contrivance.

The best Light for viewing Objects, is a clear Sky-Light, the Sun shining on any white Thing, or the Reflection of its Rays from a Looking-Glass; which last is found to be full as strong as any, and much more convenient for Use, particularly in examining Liquids; for if you hold this Microscope up to receive the Light from the Sky, your Liquid subsides, and is soon lost; but when placed in a perpendicular Position, so as the Rays of Light may be thrown from a Glass, fixed beneath it, you view it with more Ease, and less Inconvenience. For the Application of which observe,

C H A P. V.

A Contrivance for fixing Mr. WILSON's Pocket Microscope, and reflecting Light to it by a Mirrour.

A B C, Fig. 7. is a Brass Scrole, which, for the better Conveniency of Carriage, is so order'd, as to take into three Parts, and put into the Draw upon which it stands, with its reflecting Mirrour, and *Wilson's* Pocket Microscope.

The Top-Part of the Scrole is taken off at B, by unscrewing half a Turn of the Screw; then lift it up, and it comes out of the Socket. The lower Part unscrews at C, and the Base unscrews at E.

The Mirrour lifts out at F, which with the Scrole lie in one Partition of the Box.

To apply this Scrole to Use, fix the Body of the Microscope to the Top thereof, by the Screw A, as in Fig. 7. by screwing it in the same Hole as the Ivory Handle.

The Brads or Ivory Slider being fixed as before described, and the Microscope placed in a perpendicular Position; move the reflecting Glass D in such a Manner, as to cast the Light of the Sky, the Sun, or a Candle, directly upwards, through the Microscope; by which Means it is made to answer most of the Ends of a double reflecting Microscope, hereafter to be described.

It is also rendered more useful for viewing opaque Objects, by screwing the Arm Q, Fig. 6. into the Body of the Microscope, at G, then screwing into the round Hole R, that Magnifier, which you think will best suit your Object; and put the concave Speculum S, on to the Outside of the Ring R, you will find in the Body of the Microscope, between the Wood or Brads F, and the End of the Male Screw C C, a small Hole U, through which slide the long Wire T, which has a Point at one End, and Forceps at the other, that may be used occasionally, as your Object requires: When you have fixed this, and your Object on it, turn the Arm R, which is performed by two Motions, till the Magnifier is brought over the Object; it may be then adjusted to the true Focus, by turning the Male Screw C C, in the same Manner as before described. It must also be turned exactly over the Speculum, by twisting the upper Part of the Scrole to one Side, till your Object, and the two Speculums, are in one Line, as will be found by Trial, and then fix it by the Screw B, at which Time the upper Surface of the Object will be so exceedingly enlightened by the Light reflected upward from the Mirrour, to the concave Speculum, as to be seen as clear and distinct as any transparent one.

C H A P. VI.

Of the Manner of applying Mr. WILSON's Pocket Microscope, to the Solar Apparatus.

THE Solar Apparatus having been already described in the 3d Chap. it remains only to shew how Mr. *Wilson's* Pocket Microscope, is to be applied to it.

After having fixed the Apparatus to the Window-Shutter, and adjusted it to the Altitude and Situation of the Sun, so as to form a round Spot of Light on the Screen.

Screw the Tube H, Fig. 5. into the Middle of the Plate and Rings, taking Care not to alter the Looking-Glass; then screwing the Magnifier you choose to employ, to the End of your *Wilson's* Microscope, at G, Fig. 6. In the usual Manner, take away the Lens D, at the other End thereof,

thereof, and place a Slider, containing the Object to be examined between the thin Brass Plates E.

Things being thus prepared, screw the Body of the Microscope A B, by the Screw D, Fig. 6. to the short Brass Tube K, Fig. 5. which slip over the small End L of the Tube I, and pull out the said Tube I, more or less, as the Object is capable of enduring the Sun's Heat.

The short Tube K, which your Microscope is screw'd to, enables you by sliding it backwards or forwards on the other Tube L, to bring your Objects to their true focal Distance; which will be known by the Sharpness and Clearness of their Appearance: They may also be turned round by the same Means.

For the Screen, and all the other Particulars, See Chap. 3.

C H A P. VII.

Of the Microscope for Opake Objects.

A, Fig. 8. is a fixed Arm, through which passes a Screw B, the other End whereof is fastened to the moveable Arm C.

D, is a Nut fitted to the said Screw, which when turned, will either separate or bring together the two Arms A C.

E, is a Steel Spring, that separates the two Sides when the Nut is unscrewed.

F, a Piece of Brass turning round in a Socket, whence proceeds a springing Tube, moving on a Rivet, through which runs a Steel Wire, one End of which finishes in a Point G, and the other End hath a Pair of Pliers R folder'd to it; these are either to thrust into, or to take up and hold any Object; and may be turned round as required.

I, a Ring of Brass, with a female Screw fixed on an upright Piece of the same Metal, which turns on a Rivet, that it may be set at a due Distance when the least Magnifiers are used; and serves the Screws of all the Magnifiers.

K, a Concave Speculum of Silver polished as bright as possible, in the Center of which a double Convex Lens is placed, with a proper Aperture to look through it: On the Back of this Speculum a male Screw L, is made to fit the Brass Ring I, which may be screwed into the said Ring at Pleasure.

Four of these concave Specula of different Depths, are fitted to four Glasses of different magnifying Powers; to be used as Objects to be examined may require. The greatest Magnifiers have the least Apertures.

M, a round Object Plate, one Side white, and the other black, intended to render Objects the more visible, by placing them, if black, upon the white, and if white, on the black Side. A Steel Spring N, turns down
on

Fig. 6.

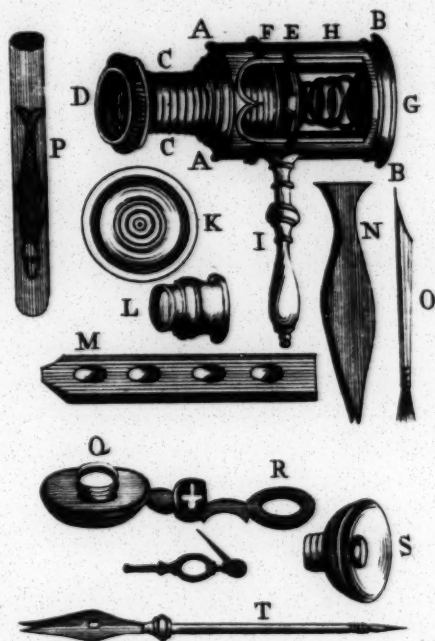


Fig. 7.

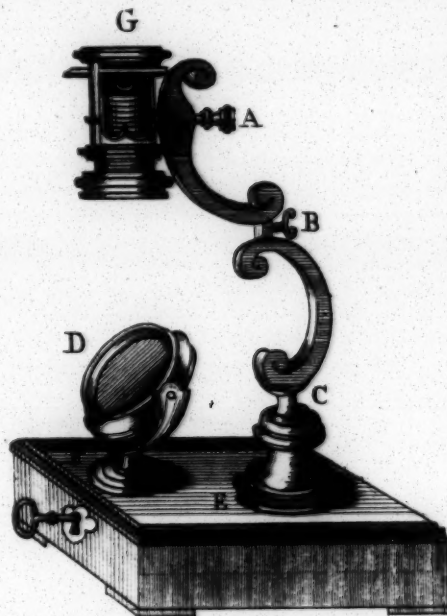
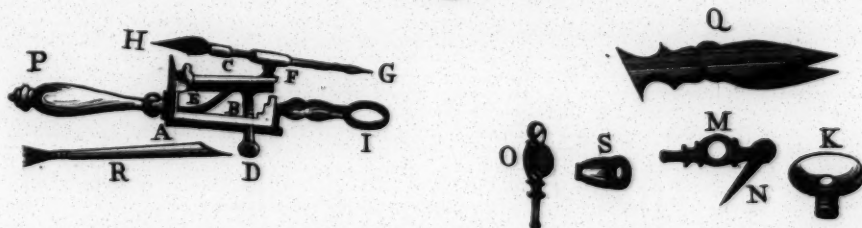
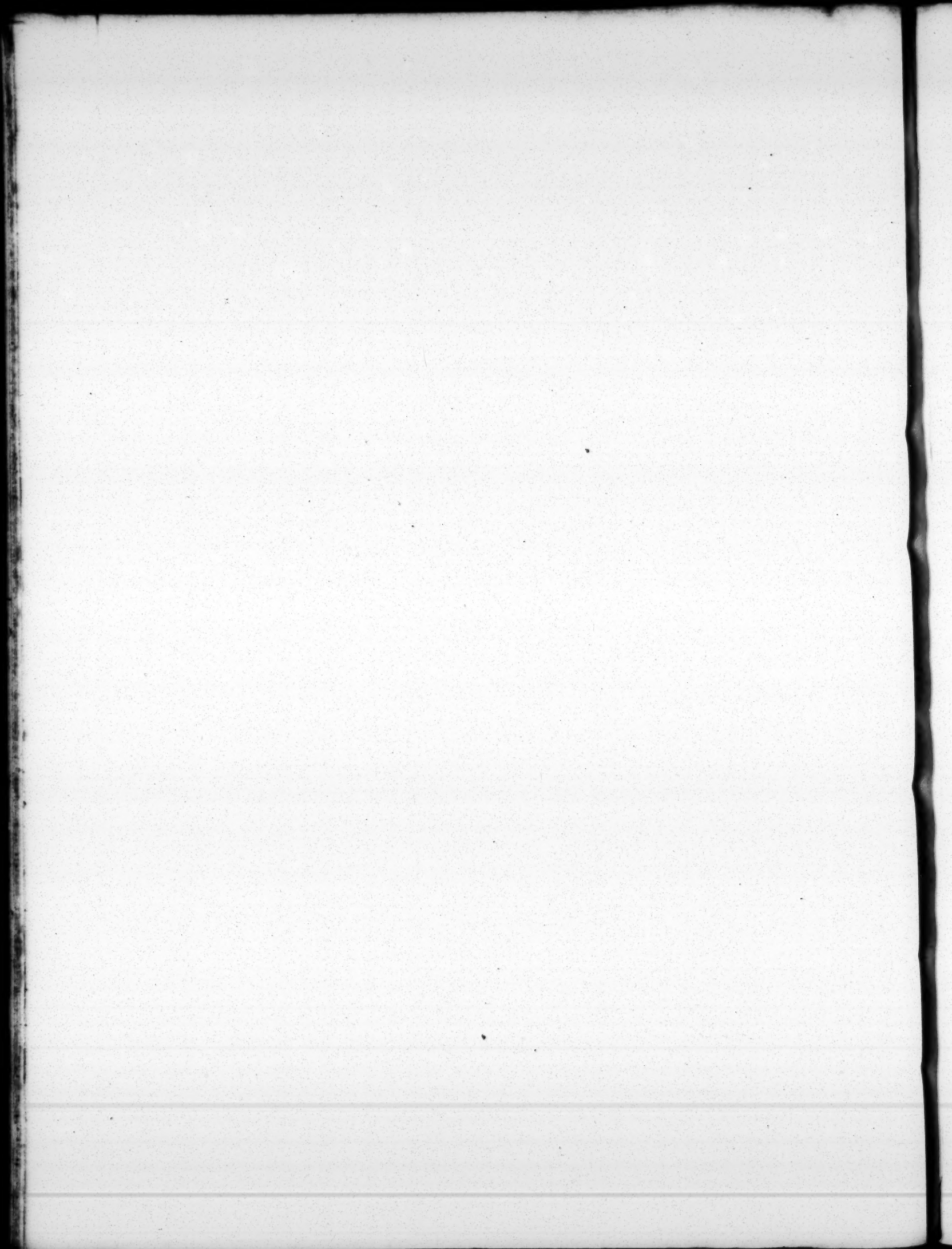


Fig. 8.





Microscope for Opake Objects.

17

on each Side to make any Object fast ; and issuing from the Object Plate is a hollow Pipe to screw it on the Needles Point G.

O, a small Box of Brass, with a Glass on each Side contrived to confine any living Object, in order to examine it ; this also has a Pipe to screw upon the End of the Needle at G.

P, a turned Handle of Ivory to screw into the Instrument when it is made use of.

Q, a Pair of Pliers to take up any Object, or manage it with Convenience.

R, a soft Hair Brush to clean the Glasses or Specula.

When you would view any Object, screw the Speculum with the Magnifier you intend to use, into the Brass Ring I, place your Object either on the Needle G, in the Pliers H, on the Object Plate M, or in the Brass hollow Box O, as may be most convenient according to the Nature and Condition of it : Then holding up your Instrument by the Handle P, look against the Light through the magnifying Lens, and by means of the Nut D, together with the Motion of the Needle, by managing its lower End, the Object may be turned about, raised, or depressed, brought nearer the Glass, or put farther from it, till you hit the true focal Distance, and the Light be seen reflected from the Speculum strongly upon the Object ; by which Means it will appear very distinct and clear.

C H A P. VIII.

A Description of the Double Microscope, commonly, though very improperly, called the Reflecting Microscope.

A B C, Fig. 9, is the Body of this Microscope, in which slides C D, the inner Tube, that contains all the Glasses. The Eye Glass is at E, the broad middle plano convex Glass at F, and the Object Glass being set in a Button at G, is screw'd upon the End of the narrower Tube I, which being fixed in the Base of the inner Tube, passes freely through a Hole in the Base of the outer.

The Buttons that contain the several Object Glasses are number'd 1, 2, 3, 4, 5, and the Convexity of the inner Tube, is also marked with dotted Circles number'd 1, 2, 3, 4, 5, in order to bring that Circle to coincide with the Mouth of the outer Tube, whose Number is the same as that of the Object Glass then made use of : But if the Object does not then appear quite distinct, slide, or rather twist the inner Tube gently, higher or
D lower,

lower, or turn the Screw of the Magnifier gradually till the Object appears distinct. The greatest Magnifiers are known by their having the smallest Apertures.

The Base B C of the outer Tube is supported by three Brass Pillars on Scroles, fixt on a Mohogany Pedestal H K, in which is a Drawer L, to hold the Magnifiers and other Parts of the Apparatus. A little below the Object-Glass is fixed a Plate M, like a Stage between the Pillars.

N, three small brass Circles with Holes thro' the Middle of them which are to be placed over the Hole in the Middle of the Stage, and then the Ivory Slider O may be put between the two uppermost, which are pressed together by a spiral springing Wire lodged between the two undermost. The two outermost being held together by four small Pillars passing through four Holes in the Circumference of the middle Circle.

P, is a Fish-pan to fasten a small Fish on, to see the Circulation of the Blood, its Tail being spread across the oblong Hole at the smallest End; then by shoving the Button inwards through a Slit made in the Stage, a small Brass Spring under the Stage will keep it steady; for viewing it the Tail may be brought exactly under the Magnifier, by turning the Pan on the Button, or by shoving it inwards or outwards along the Slit in the Stage.

All transparent Objects are well illuminated in this Microscope, either by Candle or Sky-Light reflected upwards from a concave Looking Glass R, placed in a Frame upon the Center of the Pedestal. While you are viewing the Object through the Microscope, turn this Concave upon its horizontal Poles a b, and you will soon find out that Position of it wherein it reflects the most Light through the Hole c upon the Object.

Opake Objects when laid upon the Plate s, which is on one Side black Ebony, and on the other a Piece of white Ivory, being laid over the Hole c, in the Stage may be illuminated by the Light of the Sun-shine or a Candle transmitted through a double Convex Lens a, which by turning on two Screws, e, d, and the Foot of it put into the Hole f of the Stage. The Candle must be placed in a Line drawn from the Object through the Middle of this Lens at such a Distance to be found by Trial as will form the smallest Spot of Light upon the Object Plate. By Day-light this Glass is of no Service.

T, an Ivory Cone to screw on to a male Screw under the Center of the Stage: Its Use is to intercept some Part of the oblique Rays when the first and second Magnifiers are used.

V, a Glass Tube to put a small Frog or Newt in, to see the Circulation of the Blood. When the Object is well expanded on the Inside of the Tube, slide it over the Hole c, in the Center of the Stage; and bring that Part of the Object you would examine directly under the Magnifier.

W,

W, a Cell, containing a concave and a plain Glass, is to confine Fleas, Lice, Mites, or any small living Objects, and being placed over the Middle of the Stage may be viewed with Ease.

X, a plain circular Glass to be placed over the Center of this Stage to lay any Objects on that may at any Time offer, and a loose concave Glass being laid with its hollow Side downwards, will easily confine any living Insect.

Y, a long Steel Wire with its Pliers and Point to hold or stick Objects on, slips backwards and forwards in a short Brass Tube, which by the Button fits into the Hole of the Stage, and then it may be conveniently managed under the Magnifier.

O, a flat Piece of Ivory called a Slider with four round Holes through it, and Objects placed in them between *Muscovy* Talcs.

Z, a little round Ivory Box to hold Ifinglass for the Sliders.

U, a small Hair Brush to wipe any Dust off the Glasses, or to apply a Drop of any Liquid.

J, a Pair of Nippers to take up any Object to be examined.

N. B. When the Body of this double Microscope is made of Brass, it is supported with a single Pillar, to which is fixed a sliding Bar, an adjusting Screw, and a concave Speculum for opaque Objects, &c. But as this Apparatus comes to double the Price of that just described, and being not at all better for Use, I have omitted a drawing thereof.

C H A P. IX.

Of a Single or Double Microscope, what, how it magnifies, and why.

A Single Microscope is only a very small Globule of Glass, or a double convex Lens, whose focal Distance is very short. The former being at present disus'd, I shall confine myself only to a Description of the Nature and magnifying Powers of the latter.

A thin Piece of Glass bounded on one Side by a polished plane Surface, represented by the Line E F, Fig. 10, 11, and on the other Side by a small Portion of a polished spherical Surface, represented by the Arch A C B; or bounded on both Sides by spherical Surfaces A C B E D F, Fig. 12, 13, 14. is called a Lens, or simply a Glass; and by Mathematicians is conceived to be generated or described by turning the Figure A C B F D E round about the Line C D, drawn through the Middle of it, perpendicularly to both its Sides.

This Line produced is therefore called the Axis of the Lens ; and passes through G and H, the Centers of its Surfaces.

The Points C D, where it cuts the Surfaces, are called the Vertexes of the Lens, and the middle Point between them is called its Center.

The 10th Figure represents a plano Convex, the 11th a plano Concave, the 12th a double Convex, the 13th a double Concave, and the 14th a concavo Convex, or a Meniscus Lens.

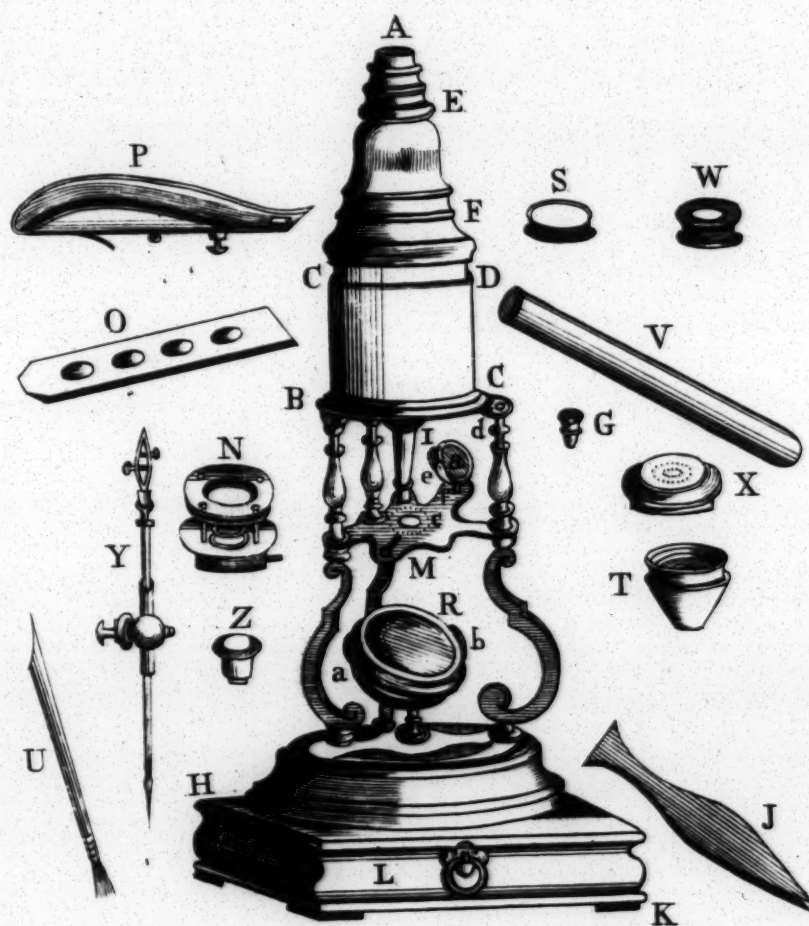
As Rays of Light are thrown out and dispersed in all possible Directions from every Point of a luminous Body ; so as they illuminate other Bodies upon which they fall, they are also incessantly thrown back from, or transmitted through every Point of these Bodies. For the Points of opaque and transparent Bodies so enlighten'd, are visible to the Eye, at any Point of Space, and in any Point of Time, as well as the Points of the luminous Body that enlightened them. The numberless Rays which flow from all visible Bodies, called Objects, are considered as consisting of so many physical Points, and these Points are conceived to radiate all Manner of Ways.

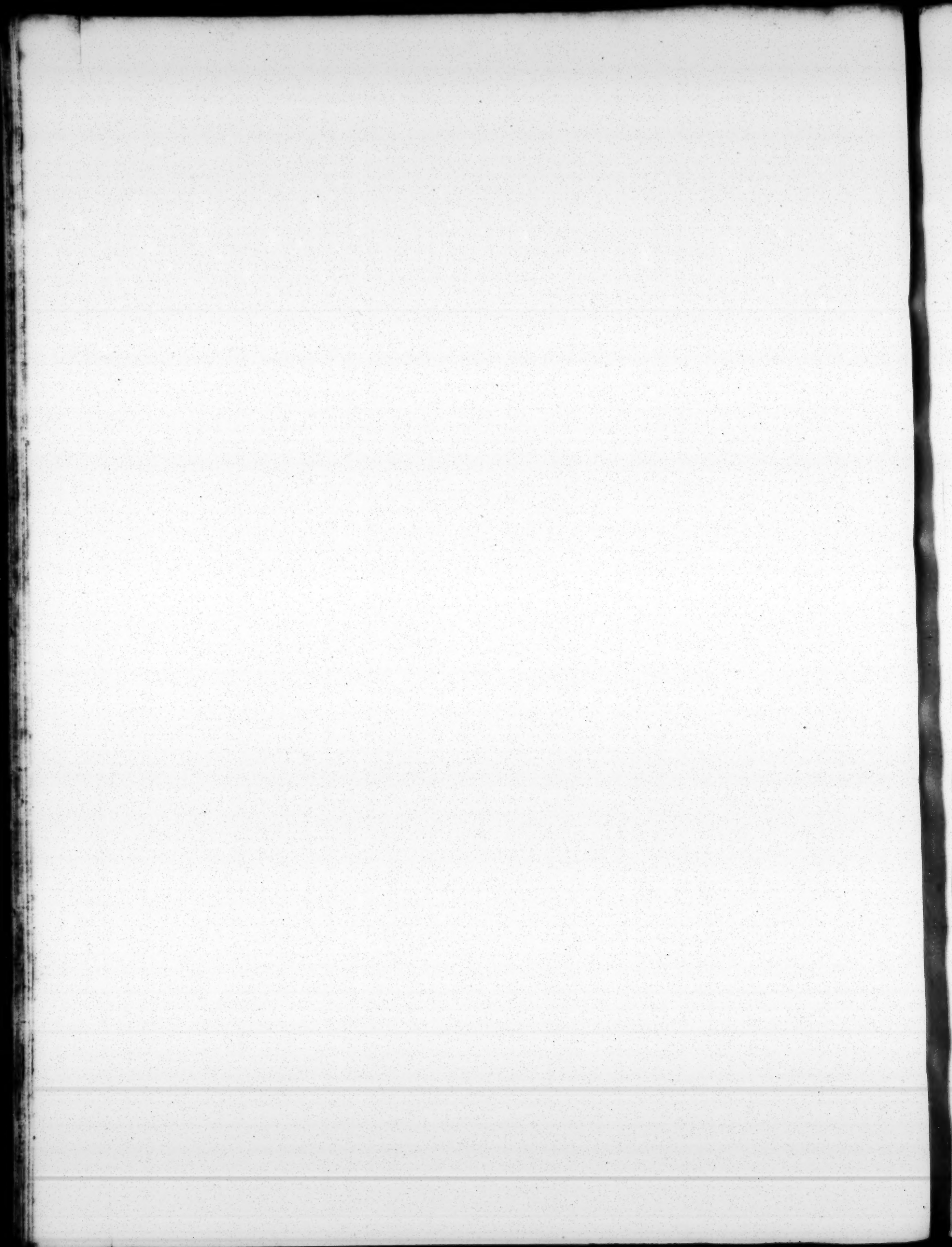
The Point Q, Fig. 15. from which Rays diverge, or towards which they converge (being made to go back towards the same Point, though they may never meet at it) is called the Focus. And in both Cases, any Parcel of these Rays, as Q B C, or Q B A considered a-part from the rest, is called a Pencil of Rays ; and these Rays are said to belong to that Focus, whether they be near at Hand, or at an immense Distance ; and in the latter Case, the Rays are called, and consider'd as parallel, or equidistant from each other ; because the Difference of their Distances at any two given Places is insensible, * as those from the Sun, and other vastly distant Objects. A B, Fig. 16. represents such parallel Rays, which falling upon the Lens C D, are made to approach nearer and nearer together in their Progress ; tending to one certain Point, where they all unite. Thus the Rays proceeding from the Lens C D, to the Point E, are called converging Rays ; and the Point E their Focus, where they cross, and continually recede from each other as they pass along. So that those Rays flowing from the Point E, towards F G, are called diverging Rays.

Let A B, Fig. 17. be a double convex Lens, E F the Object at its Focus C ; G, the Eye very near the Lens E F, the Rays coming from the Object, will, after their Refraction, fall parallel † upon the Eye, and consequently make distinct Vision. For the Fabrick of the Eye having its focal Distance just at the Bottom of it, upon the Retina, requires that the Rays from each single Point, should fall nearly parallel, in order to be there collected ; that is, that the Basis of each Cone of Rays, flowing from every

* *Smith's Opt. p. 6.* † *Greg. Opt. 170.*

Fig. 9.





Point of an Object, which Basis is the Pupil of the Eye, should bear so small a Proportion to the Length of the Cone, as that these Cones may be looked upon as little Cylinders. The Distance requisite for distinct Vision, is not limited to a Point, but is indulg'd in larger Bounds; because Nature has furnish'd us with the Power of contracting the Pupil, as the Object comes nearer; and so diminishing the Basis of each Cone in Proportion, and consequently of preserving distinct Vision; but this is only to a certain and that no very great Degree.

Therefore a minute Object *E F*, seen distinctly thro' a small Glass Lens *A B*, by the Eye put close to it, appears so much greater than it would to the naked Eye; placed at the least Distance *E D*, from whence it appears sufficiently distinct, as this latter Distance *E D*, is greater than the former *E C*; for having put your Eye close to the Glass *A B*, in Order to see as much of the Object as possible at one View, remove the Object to and fro till it appears most distinctly, suppose at the Distance *C E*, then conceiving the Glass *A B*, to be removed, and a thin Plate *A B*, with a Pin-hole in it, Fig. 18. to be put in its Place, the Object will appear distinct, and as large as before when seen thro' the Glass, only not so bright. For if the Hole be so small as to admit but a single Ray, from every distinct Point of the Object, these Rays will fall upon the Retina, in as many other distinct Points, * and will make a distinct Picture †; and when the Pencils of Rays fall upon a thin Lens, their Axis go strait thro' the Middle of it, and consequently will proceed to the same Points upon the Retina, as when they passed thro' the Hole. Now supposing the Lens to have such a Figure, that the Rays of every Pencil shall be refracted by it, and by the Eye together, to those very Points of their Axis which touch the Retina, the Picture will still be distinct; and will be the same in Magnitude and Position as before. The only Difference in the Effects, between the Hole and Lens, will be in the Degree of Brightness upon the Retina. And in this latter Case, the Object appears so much greater than it does to the naked Eye, at the Distance *E D*, either with the Pin-hole, or without it; as the Angle *C E F*, is greater than the Angle *A D E*, or as the latter Distance is greater than the former.

Since the Interposition of the Glass has no other Effect than to render the Appearance distinct, by helping the Eye to increase the Refraction of the Rays in each Pencil, it is plain, that the greater apparent Magnitude is entirely owing to a nearer View than could be taken by the naked Eye. If the Eye be so perfect, as to see distinctly by Pencils of parallel Rays falling upon it, the Distance *C E* of the Object from the Glass, is then the focal Distance of the Glass.

* *Greg. Opt. p. 171..* † *Smith, Opt. p. 37.*

Now if this *focal* Distance of the *Lens*, be $\frac{1}{8}$ of an Inch, and if the Distance E D be 8 Inches from the Object, the usual Distance at which we view minute Objects, the apparent Image, or Diameter of the Object, may be said to be so much magnified, as those 8 Inches exceed the little Space C E, or the *focal* Distance of the *Lens* A B, which is at the Rate of 40 to 1. Therefore the less the *focal* Distance of the little *Lens* is, the greater will its Effects be in dilating the Image of a small Object; (for if its *focal* Distance be yet smaller, suppose $\frac{1}{80}$ of an Inch; the Diameter or Length of an Object will appear 160 Times longer thro' such a *Lens*, than to the naked Eye, at 8 Inches; its Surface 15600 Times greater, and the Solidity or Bulk would be magnified to 2,496,000 Times) inso-much that its *focal* Distance may be shortened, till it is reduced to an infinitely small *Spherule*. Tho' there are some Inconveniencies which here offer themselves, and forbid our going beyond certain Limits; for these small *Spheres* are inferior to little *Lens*'s, on this Account, that for the same Degree of magnifying, the *Lens*'s are three Times more distant from the Object than the *Spheres*, the Effects of which are thus demonstrated. Let there be a Glass *Sphere*, Fig. 19. whose Center is A, and Axis B D, in which, produced on both Sides, the Eye is placed at H, and the Object at C, each of the Distances B H, D C, being taken equal to half the Radius A B, and consequently the Point C is the *Focus*, where Rays falling parallel to the Axis B D, upon the Sphere at B G, are after Emmerfion collected. Wherefore an Object placed at C, will send Rays upon the Sphere, which will, after Refraction, be received parallel by the Eye, and consequently make distinct Vision. But if we take the Point L, such that L B may be equal to the Radius A B, the Point L is the *Focus*, towards which parallel Rays, after Refraction, at the first Surface D E tend in their Passage through the Sphere, and from which they are diverted after Refraction at their Emmerfion, and collected at H. Make E F parallel to the Axis, and comprehending the Portion of the Object C F, and draw the right Line F H. The Ray F E being refracted at E, proceeds according to E L, and being again refracted at G, goes on to meet the Eye at H, wherefore the Line C F is seen under the Angle B H G, and would appear to the naked Eye under the Angle C H F, which is but half the former Angle.

Because B L is double to B H, the Angle B H G is double to B L G, but H L is parallel to F E, and to be looked upon as equal to it, or to the right Line D C; because C F is to be a Line very small, with Respect to the Diameter of the Sphere. Therefore the Angle B H G is also double of the Angle C H F, and consequently equal to the Angle C A F. From whence it is plain, that to the Eye placed at H, the Line C F will appear under the same Angle, in which it would appear to the naked Eye, seeing from the Point A. Whence if the Diameter of the little Sphere B D, were $\frac{1}{16}$ of an Inch, we should have A C equal to $\frac{1}{8}$ of an Inch; which

is to the Distance of 8 Inches in the Proportion of 1 to 128, so that the Magnitude of the Object will be increased 128 Times.

But if K E, the *focal* Distance of the *Lens* M N, Fig. 20. be equal to the right Line A C of the last Figure; we have shewn, that by this Means the Object L P would be seen in the same Magnitude, as if the Eye were placed at K, without the *Lens*; nor in using this *Lens* will the apparent Magnitude be any Ways changed, in whatsoever Part of the Axis K E, produced, the Eye be placed. Therefore, 'tis plain the same Degree of magnifying, and the same Effect every Way is performed equally by the *Lens* M N, Fig. 20. and the little *Sphere* B D, Fig. 19. and it is also manifest, that the Distance K L, is equal to thrice D C, Q E D.

If an Object A B be placed in one *Focus* of a *Lens* M N, Fig. 21. and the Eye in the other *Focus* D; so much of the Object as is equal to the Diameter of the *Lens*, will be seen by the Eye, for the Rays A M and B N, which flow from the Object to the Extremities of the *Lens*, proceed from thence converging, till they meet at D the *Focus*; must necessarily pass from the Object to the *Lens*, parallel to the Axis, and therefore parallel to each other. Consequently that Part only of the Object A B, seen by the Rays M D, and N D, will be equal to the Diameter of the *Lens* M N.

If the *Lens* be covered with a thin Plate, and only the Part m n, Fig. 21. be left open, then only so much of the Object a b, as is equal thereto, will be perceived by the Eye. For as A B is equal to M N, or a b to m n; the Angle M D N, or m D n, is the Measure under which Part of the Object A B, or m n appears to the Eye at D.

In order to see a larger Portion of an Object than the *Lens*, or its *Aperture*; the Eye must be placed nearer the *Lens*, than its *Focus*; for, let the two *Foci* of the *Lens* M N, Fig. 22. be H and G. Let an Object A B be placed in the last *Focus*, larger than the *Lens*. The Rays proceeding from the Extremities A B of the Object, towards the *Lens*, will, after Refraction, unite in the Point C, between the *Lens* M N, and its *Focus* H. Therefore if the Eye be placed at C, its Field of View or Portion of an Object, will be greater than the *Lens* M N.

If E F be a Portion of an Object less than the *Lens*, the Rays E M, E N, produced to the Extremities of the *Lens*, will after Refraction unite in a Point D, farther distant from the *Lens*, than the *Focus*. From whence it appears, that if the Eye be placed farther from the *Lens* than its *Focus*, it cannot see any Part of an Object so large as the *Lens*, but always smaller.

Therefore, in the *Universal Single Microscope*, I have contrived the Manner of fixing the Magnifiers, which are *Double Convex Lens's*, so as to admit the Eye to be placed almost close to them, by which Means we always see a Portion of an Object larger than the *Aperture*

ture of the Lens. And in this Way of using single Lens's, microscopick Objects appear exceedingly distinct and clear, and are in all Respects far preferable to the Double Microscopes, which are compos'd of three convex Glasses.

Upon the *Apertures* of *Microscopes*, all their Effects and Virtue entirely depend. It is therefore to be observed, that in single *Lens's*, if their *focal* Distance be about $\frac{1}{2}$ an Inch, or greater, there will be no Occasion for limiting the *Aperture*, in order to make distinct Vision; because the very Narrowness of the Pupil of the Eye excludes as many of those Rays which disturb Vision, as is necessary, and as much as they would be excluded, if the *Lens* were made to have a less *Aperture*. But in smaller *Lens's*, where this Limitation of the *Aperture* is necessary, the Rule is, that the Diameters of those Apertures should be in the same Proportion with the *focal* Distances of their respective *Lens's*, in order to have the Object seen by both equally distinct. But the *Light* or *Brightness* will be in a duplicate Proportion of those *focal* Distances *; so that the more convex the *Lens* is, the greater indeed, but then the more obscurely will the Object be seen.

In my *Universal Microscope*, I have contrived the black Eye-Piece N, in such a Manner, as to receive any *Lens*, whose *Aperture* wants no Limitation, and have taken Care to limit all the Apertures of the six Magnifiers, so as to admit as much Light as possible, without destroying distinct Vision, an Advantage which few of the modern Microscopes have.

In order to find the magnifying Power of any *Lens*, we need only find its exact *focal* Distance in 100th Parts of an Inch (which is easily done by setting a minute Object in the Microscope, so as to appear perfectly clear and distinct; this Distance measured on a Scale of an Inch, divided into 100 Parts, will give its true focal Length;) and by computing how many Times those Parts are contained in 8 Inches, we shall have the Number of Times the Diameter of an Object is magnify'd to, and that Number multiplied into itself, will produce the Magnitude of the Superficies, which Product, multiplied by the Diameter, will shew the Solidity or magnified Bulk.

It was with these Sorts of single Microscopes, that the famous Mr. *Leeuwenhoek* made such wonderful Discoveries; and it was this Consideration which induced me to contrive an Apparatus that should make these single Microscopes easy in Use, to those Gentlemen whose Curiosity leads them to search into the *minute Recesses* of *Nature*, and thereby be taught to contemplate and adore the wonderful and surprizing Contrivance of *Nature's ALMIGHTY Architect*.

* *Gregory's Opt.* p. 184.

Of Double Microscopes.

A double Microscope is composed of two convex Glasses, placed at E and L, Fig. 23. the Glas L next the Object P Q is very small, and very much convex, and consequently its focal Distance L F is very short; the Distance L Q of the small Object P Q, is but a little greater than L F; so that the Image p q may be formed at a great Distance from the Glas, and consequently may be much greater than the Object itself. This Picture p q being viewed through a convex Eye-Glas A E, whose focal Distance is q E, appears perfectly distinct. Now the Object appears magnified upon two Accounts, first, because if we view its Picture p q with the naked Eye, it would appear as much greater than the Object at the same Distance, as it really is greater than the Object, or as much as L q is greater than L Q; and secondly, because this Picture appears magnified through the Eye-Glas, as much as the least Distance, at which it can be seen distinctly with the naked Eye, is greater than q E, the focal Distance of the Eye Glas. For Example, if this latter Proportion be 5 to 1, and the former of L q to L Q, be 20 to 1, then upon both Accounts the Object will appear 5 times 20, or 100 times greater than to the naked Eye.

To fit these Microscopes to short-sighted Eyes, the Glasses E and L must be placed a little nearer together; so that the Rays of each Pencil may not emerge parallel, but may fall diverging upon the Eye; and then the apparent Magnitude will be alter'd a little, but scarce sensibly.

In the last Example, let us suppose the Eye-Glas E A to be 1 Inch $\frac{6}{10}$ Focus, which will be found exactly 5 times in 8 Inches, the Distance at which the same Object would be seen distinct by the naked Eye. Therefore this Eye-Glas magnifies 5 times; and if the Object Lens L, has for its Focus L Q $\frac{1}{4}$ of an Inch, and the Picture be formed at P q, whose Distance L q is 5 Inches, the Picture will be magnified 20 times; because the Distance L Q $\frac{1}{4}$ of an Inch is contained 20 times in L q, 5 Inches; and this Picture magnified 5 times greater (as appears above) by the Eye-Glas E A, and therefore 5 times 20, that is 100 times.

The Length being magnified 100 times, the Surface of Objects will be magnified 10000 Times, and their Solidity or Bulk 1000000 times.

Altho' we can readily, by this Method, find out the magnifying Powers of the several Sorts of Microscopes, yet our Notions of the comparative Smallness of any minute Object, must be assisted by a larger one, whose Dimensions we know, and by finding how many Times the lesser is contain'd in the greater; which shall be the Subject of the remaining Part of this Chapter.

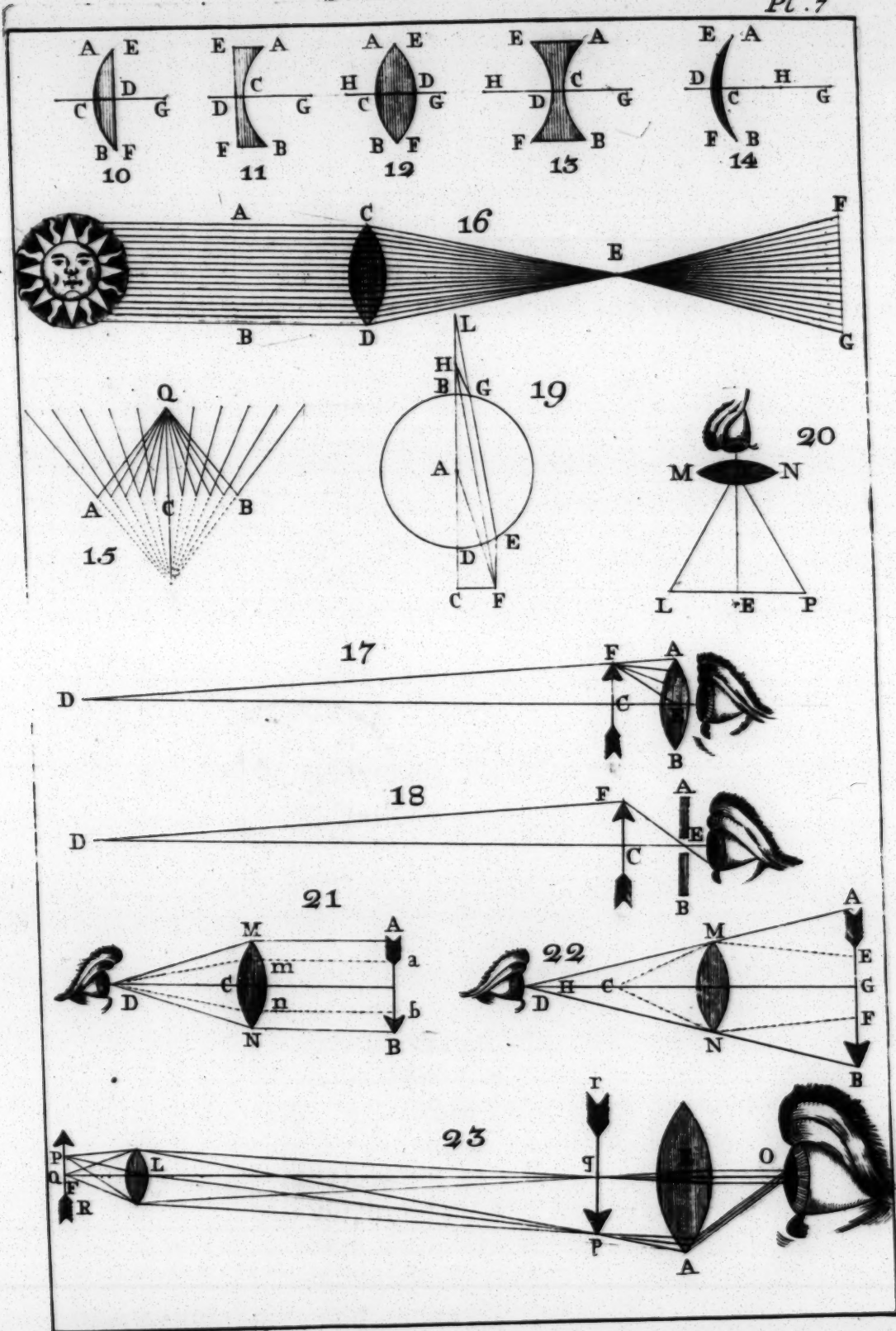
Mr. *Hook's* Method of computing the Magnitude of Objects, seen in the *Microscope*, was, after he had adjusted the *Microscope*, to see the Object very distinctly: At the same Time that he look'd upon the Object thro' the Glass with one Eye, he looked upon other Objects at the same Distance with his other bare Eye, by which Means he was able, by the Help of a Rule divided into Inches and small Parts, * and laid on the Pedestal of the *Microscope*, to cast up, as it were, the magnified Appearance of the Object upon the Rule, and thereby exactly to measure the Diameter it appears of through the Glass; which being compared with the Diameter it appears of to the naked Eye, will easily afford the Quantity of its magnifying. This Method is very easy to those Persons who can accustom themselves to such a Practice, I mean of observing two Objects at the same Time, one of them with one Eye by direct Vision, and the other by refracted Vision, through the Glass. It is indeed a Method I have practised with Success to estimate the magnifying Power of Telescopes for many Years.

The Method Mr. *Leuwenhoek* made use of to compute the Size of Animalcules in Water, in *Semine Masculino*, the *Salts* in Fluids, &c. was by comparing them with a Grain of Sand, one hundred of which laid in a Row, will but just equal an Inch in Length. Then conceiving one single Grain of Sand, magnified to the Bigness of Fig. 24. A B C; and seeing an Animalcule swimming, or running by, or across it, the Magnitude of Figure D. The Axis of which he estimates by his Eye, and concludes it to be a twelfth Part of the Axis D C of the Grain of Sand. From whence it follows by the common Rules, that the Figure of the Body or Sphere A B C, is 1728 times larger than the Sphere D.

Also amongst the rest, he sees a second Species of Animalcules E, the Diameter of which, by the Help of a very good *Microscope*, he also measures, and estimates it to be a Fifth; but lest he should exceed, sets it down to be only four times less than the first Animalcule D; therefore according to the former Rules, the Animalcule D is 64 times larger than that of E. Likewise upon a closer View, he sees a third Species of Animalcules F, still less than the second, whose Diameter he measures by Estimation as before, and judges it to be 10 times less than the Diameter of the Animalcule E. Therefore the Animalcule, Fig. E, is 1000 times bigger than that of F.

In multiplying the first Sort by the second, and that again by the third, will plainly shew how many of these last are required to fill a Sphere no bigger than a Grain of Sand, viz.

* Preface to *Hook's Mycographia*, printed Anno 1675.





Microscopes explain'd.

27

Diameter of D 12 times less than a
12 Grain of Sand.

144
12

1728 in a Grain of Sand.

Diameter of E 4 times less than
4 that of D.

16
4

Sort D.
64 in one of the first

of Sand.

The third Sort F, whose Diameter
is less than that of E,
10 times

10

100

10

1000 in one of the 2d Sort.

1728 of the first Sort D in a Grain
64 of the second Sort E in one
of the first Sort D.

6912

10368

110,592

1000

of Sand.
of the 2d Sort E in a Grain
of the 3d Sort F in one
of the 2d.

110,592,000 of the 3d Sort F, contained
in a Sphere no bigger than a Grain of Sand *.

The ingenious Dr. *James Jurin*, in his excellent Dissertation on *Physico Mathematical Subjects*, Pag. 45. has taught us a more accurate and ready Way of measuring microscopick Objects; as follows,

He first twists a very fine silver Wire a great many times upon a slender Pin, so closely as to leave no Interval between the Wreaths, which he carefully examines by a magnifying Glass; then he takes the Interval of the outermost Wreaths, between the Points of a Pair of fine Compasses, and applies this Extent to a diagonal Scale of Inches, and by dividing this Measure of that Extent by the Number of Wreaths therein contained, he obtains the Thickness of the Wire itself. Then cutting it into very small Bits, and scattering them upon the Object-Plate, he places the Object upon them, if transparent; or the Wires upon the Object, if it be opaque; and by the Eye he compares the Parts of the Object, with the Thickness of those Wires that happen to lie contiguous to them.

Thus he observed, that 4 Globules of human Blood would generally cover the Breadth of a Wire, which he had found to be $\frac{1}{483}$ Part of an Inch, and by Consequence, that the Diameter of a single Globule was $\frac{1}{1940}$ Part of an Inch, which was also confirm'd by Mr. *Leeuwenhoek's* Observations upon human Blood, made with a Piece of the same Wire transmitted to him from Dr. *Jurin*. *Philos. Transf.* N^o 377.

This Method of Dr. *Jurin's* gave Rise to another which I have contrived, that is, a Method of straining a few of these small Silver Wires, in

* Vide *Leeuw. Exp. & Contemp.* Tom. IV. Pag. 23.

form

form of a Lattice ; in such a Manner, that the Distances between the Wires are exactly equal to the Diameter of the Wire itself. By which Means having a Wire, whose Diameter is a certain known Part of an Inch, we may be able to measure a very small Animalcule, &c. and be more exact in our Calculations, than by either of the former Methods. For by placing this Lattice of Wires, close under a *Muscovy* Talc, upon which the Object may be placed, if it be transparent, or placing the Lattice over the Object, if it be an opake one. And when the Object is adjusted to the Magnifier, the Parts thereof may be easily compar'd with the Number of Wires and Intervals, and their true Magnitude, or Dimensions very nearly known, or if I observe the Diameter of an Object to be just the same with one Wire, or an Interval, I know it is the 560th Part of an Inch, supposing the Wire of that Size. If half that Width, the 1120th Part of an Inch ; if one Quarter of the Width, the 2240th Part of an Inch, and so on *ad infinitum*.

Or thus, if an Object cover but the 6th Part of the Diameter of a Wire or Interval, it will be but 3360th Part of an Inch in Diameter, which multiplied into itself, will shew the Superficies to be the 11,289,600th Part of an Inch, and that Product multiplied by the first Number will shew the Solidity to be the 37933,056,000th Part of an Inch, and thus may the Minuteness of any Object be exactly determined.

However, this last Method, tho' infinitely better than any other in Practice amongst us, is still deficient on this Account ; if the Object be considerably less than the Diameter of one single Wire or Interval between the Wires, we are obliged to estimate, or guess its Proportion to that Diameter or Interval ; but if the Object be no smaller than one fourth Part of such Interval, the Eye is able to determine that to the utmost Exactness possible.

I have, therefore, to remove this Deficiency, invented a particular and curious Micrometer, applicable both to single and double Microscopes, but particularly adapted to my *Universal Microscope*, described Fig. 1, and 3.

The magnifying Power of the solar Microscope, is found by reckoning how many Times the focal Distance of the Magnifier is contain'd between it and the Distance of the Screen, or Sheet, upon which the Image of an Object is cast. For Instance, let us suppose the *Focus* of the *Lens* in Use, to be $\frac{1}{4}$ of an Inch, and the Screen set at the Distance of six Feet, and as the focal Length of the Lens will be contained 288 times in the Screen's Distance, the Diameter of an Object is magnified in the Proportion of 288 to 1. The Superficies 82,944 times, and its Solidity, or Bulk 23,887,872 times, and by removing the Screen farther off, the Object may be magnified to almost what Size you please.

C H A P. X.

Of chusing, preparing, preserving, and applying Objects to the Microscope.

WE must be very curious in chusing such *Objects* as are proper for the MICROSCOPE, which are either small Parts of larger Bodies, or exceeding small Insects, *Salts, Sands, Seeds, Farina of Flowers, &c.* or the Interstices between the solid Parts of *Bodies*, as *Minerals, Shells, the Air Vessels in Vegetables, Pores in the Bones, Skin, &c. of Animals*, or the Motion of the several Parts of minute Animals, or of the *Fluids in Animal or Vegetable Bodies*.

The greatest Care imaginable should be taken in preparing *Objects* for an Examination; otherwise the best skill'd in magnifying Glasses may be misled, if they give too sudden a Judgment on what they see, without assuring themselves of the Truth by repeated Experiments.

If *Objects* are flat and transparent, the best Method is to inclose them between two *Muscovy Talcs*, in an Ivory Slider, as the *Farina of Flowers, Scales of Fishes, Wings of Butter and other Flies, &c.* the Bodies of *minute Insects, &c.* By this Method, every Virtuoso may always have ready two or three Dozen of these *Ivory Sliders*, furnished with the most curious *Objects*; which will be a most delightful natural History of the surprizing Beauty, Perfection, and Contrivance, we find in the Works of Nature.

In collecting *Objects* for the Ivory Sliders, Care should be taken to put those into the same Slider, which are of the same Degree of Transparency and Size; that they may all be viewed with the same Magnifier. There is a convex Glas of about an Inch Focus to hold in the Hand, in the Case with my *New Universal Microscope*, by the Help of which you may adjust the *Objects* properly between the Talcs, before you fix them down with the Brass Rings; the Number of the Magnifier may be also marked on each Slider its *Objects* are fittest for. Many small living Objects may be placed in this Manner between the Talcs, such as *Mites, small Spiders, Lice, Fleas, &c.* without being killed or hurt, and will remain alive several Days in this Manner. But for present Examination, these as well as larger *Objects*, may be put into the *Glass Slider V*, Fig. 2. described Page 4, and designed for that Use, or in the jointed Cell X, Fig. 2. Page 4, or else stick them upon the Pin l, or pinch them between the Nippers m of the Apparatus V. Fig. 2.

The *Animalcula in Fluids*, may be examined in a small Drop, taken up with a Pen or Hair Pencil, and placed in the Glas Slider before described, Page 3, or on the single Glas Slider R, Fig. 2. if in viewing them you find them (as is often the Case) so exceedingly numerous, that
by

by their continual running over one another, their Shape cannot be distinguished: Some Part of the Drop must be taken off the Glass, and a little fair Water put to the rest, which will separate, and make them appear distinct. It is necessary thus to dilute, with fair Water, the *Semine Masculinum* of all Animals; otherwise their Shape cannot be discovered, they are so crowded together in such infinite Numbers.

If *Salts* in *Fluids* are to be view'd, you must let the Fluid evaporate, that the *Salts* may be left behind upon the Glass, and be more easily examined.

For viewing the *Circulation* of the *Blood* in the Tails of *Fishes*, in *Frogs*, *Newts*, &c. they are sometimes put into Glass Tubes, but my *Universal Microscope* hath a particular Contrivance a b f, of Fig. 2. described Page 3, proper to hold down the Tails of *Newts* and *Fishes*, and the filmy Membrane between the Toes of a Frog's hind Foot; the *Circulation* is best seen in the *Mesentery*, or thin transparent Membrane, that joins the Guts together, and this Part, by pulling out the Gut a little, may be easily adjusted to the Magnifier, by Help of an Apparatus hereafter to be described, which is another Method quite new, and never before applied in so easy a Manner.

Patience and Dexterity are required to dissect Insects, and view their internal Structure, such as *Gnats*, *Mites*, *Lice*, *Fleas*, &c. which will be easily done with a fine Needle and a Lancet; if they are placed in a Drop of Water, their Parts will then be separated with Ease; and the Stomach and Bowels lie plainly (before the Microscope) to be viewed and examined.

Bits of different colour'd Glass are necessary for this Purpose, to place *Objects* on, because many *Objects* are much more distinguishable, when placed on one Colour, than on another. Glass Tubes of all Sizes, are likewise of Use, from $\frac{1}{2}$ an Inch Bore to a fine Capillary.

It is also necessary to have a few *Glass Tubes*, ready prepared, with Cork Stoppers, one at each End, each Cork having a Bit of a small capillary Tube, run thro' its Center, as at Fig. 25. in this Manner *pregnant Insects* may be kept alive till they lay their Eggs; and their *Worms* or *Maggots* after they are hatched, till they pass thro' their several Changes; and in such *Glass Tubes* it is, that Mr. *Leeuwenhoek* made his greatest Discoveries: They are more particularly described in the 2d Section of the 19th Chapter, and are to be applied to the *Universal Microscope*, between the Object-carrying Plate I, and Springs b.

Fig. 27. is a very short cylindrical Glass, which may be filled with Water, or any other Liquid, in order to examine *Aquaticks*, which are too large for the Slider S.

Fig. 26. A rectangular Box having its two broadest Sides of Glass, is design'd on Purpose to be filled with Water, in order to apply *Aquaticks* to the solar Microscope.

These

These two last are also to be placed between the Springs b, and Object-Plate I.

Fig. 28. Is another Contrivance to place transparent *Objects* between two circular Plates of Ising-Glass, one of them being divided into Partitions, by pasting a cut Paper to it, whereon the Partitions are number'd, having different Objects placed between them, and covered with another Talc, which is held down by a Brass Ring, as in the Ivory Sliders. This is a concise Way of keeping a great Number of *Objects*, ready to shew a Friend at all Opportunities; so that any Person who is desirous to preserve a large Collection of *Objects*, may have as many of these, or of the Ivory Sliders, as he thinks proper. They are to be applied to the *Universal Microscope*, between the Object-Plate I, and Springs b; the two Brass Ribs to which the Springs are fixed, being filed into concave circular Arches for their Reception, they may be turn'd round at Pleasure, and by pushing the Object-Plate either nearer to, or farther from the Pillar E, any *Object* contain'd between them will be easily brought under the Magnifier.

There is no better Way to preserve transparent *Objects*, than placing them between two *Muscovy* Talcs in Sliders, or in the circular Talc-Plates, Fig. 28.

And the very best Way of preserving opake *Objects* for those Gentlemen who are desirous to keep a Collection of them, is to prepare small thin Slips of Ivory, or rather Holly, about an Inch long, and $\frac{1}{16}$ of an Inch wide, and some a little broader, according to the Size of the *Objects* to be put thereon. Which Slips being stain'd of several Colours, we shall obtain a Contrast to almost any Colour, and by fixing Objects upon Colours the most contrary to themselves, they will be seen to the best Advantage.

I have contrived these chiefly for my new *Universal Microscope*, to be applied between the Nippers, under the reflecting Speculum O, Fig. 1.

Wet the Slips about half their Length with strong, but very transparent Gum-Water, and upon that stick on your Objects.

I have also contrived a little Ivory Box, in Form of a Parallelopiped, to keep these Slips in. In the Sides of which there is cut small Curfs, to receive the Ends of these small Ivory Slips, that they may be placed three or four of them in a Row, and also so high above each other, as that the upper Row shall not touch the Objects in that next under it.

I have prepar'd some of these little *Cabinets* for opake *Objects*, which contain some 30, some 60, &c. of those Slips, which when stored with *Objects*, will be always ready for Examination, and may be carried from Place to Place, without doing the least Injury to the Objects therein contain'd.

The Reader may be supplied with these *Ivory* and *Holly Slips*, *Cabinets*, *Ivory Sliders*, *Talc Rings*, short cylindrical *Glasses*, *rectangular Boxes*, with *Glass Sides*, circular *Ising-Glass Plates*, and *Glass Tubes*, all together in one Box,

Box, or separate if he pleases, at my Shop, the Sign of *Tycho Brabe's* Head, the Corner of *Racquet-Court*, in *Fleet-Street*, LONDON.

Having described the new invented *Universal Portable Microscope*, together with its Application to the solar Apparatus; and the other Sorts which are most in Use amongst us: By which the Reader will be able to determine how much easier it is in all its Applications than any, nay all of them taken together are, and have also shewn how to calculate their magnifying Powers, and how to prepare and preserve Objects: I shall next proceed to shew what wonderful and surprizing Discoveries have been made by the Microscope. In the Process of which, I shall not only present the Reader with a Variety of Copper-Cuts, of most of the minute Insects and Animalcules that have been observed by Mr. *Hook*, Mr. *Leeuwenhoek*, Mr. *Joblott*, myself, and others, but also shew how to apply either the whole, or the several Parts thereof to the Microscope. In doing of which I have spared neither Cost nor Pains to make the Work compleat.

C H A P. XI.

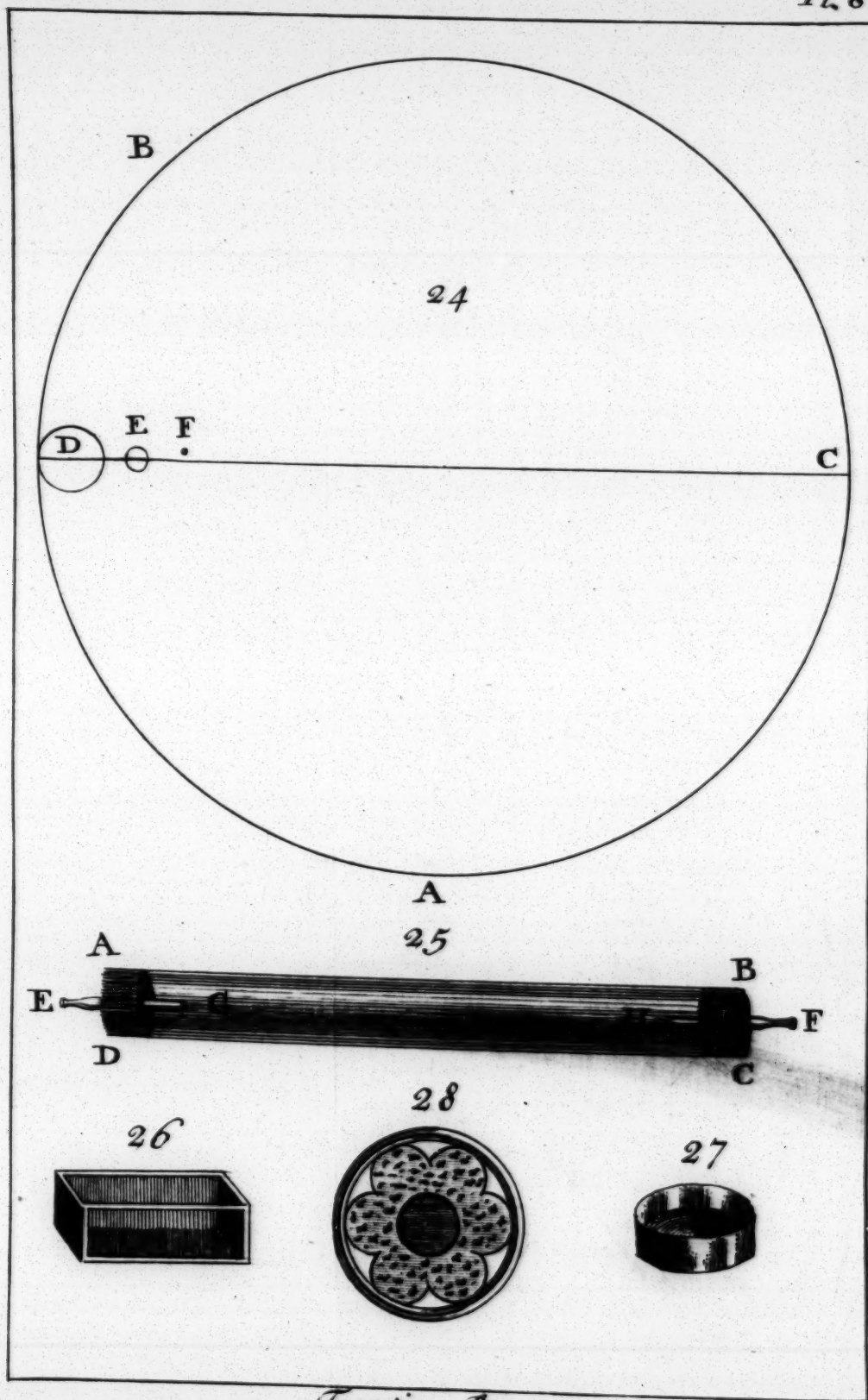
Of the Circulation of the Blood, and how to examine it by the Microscope.

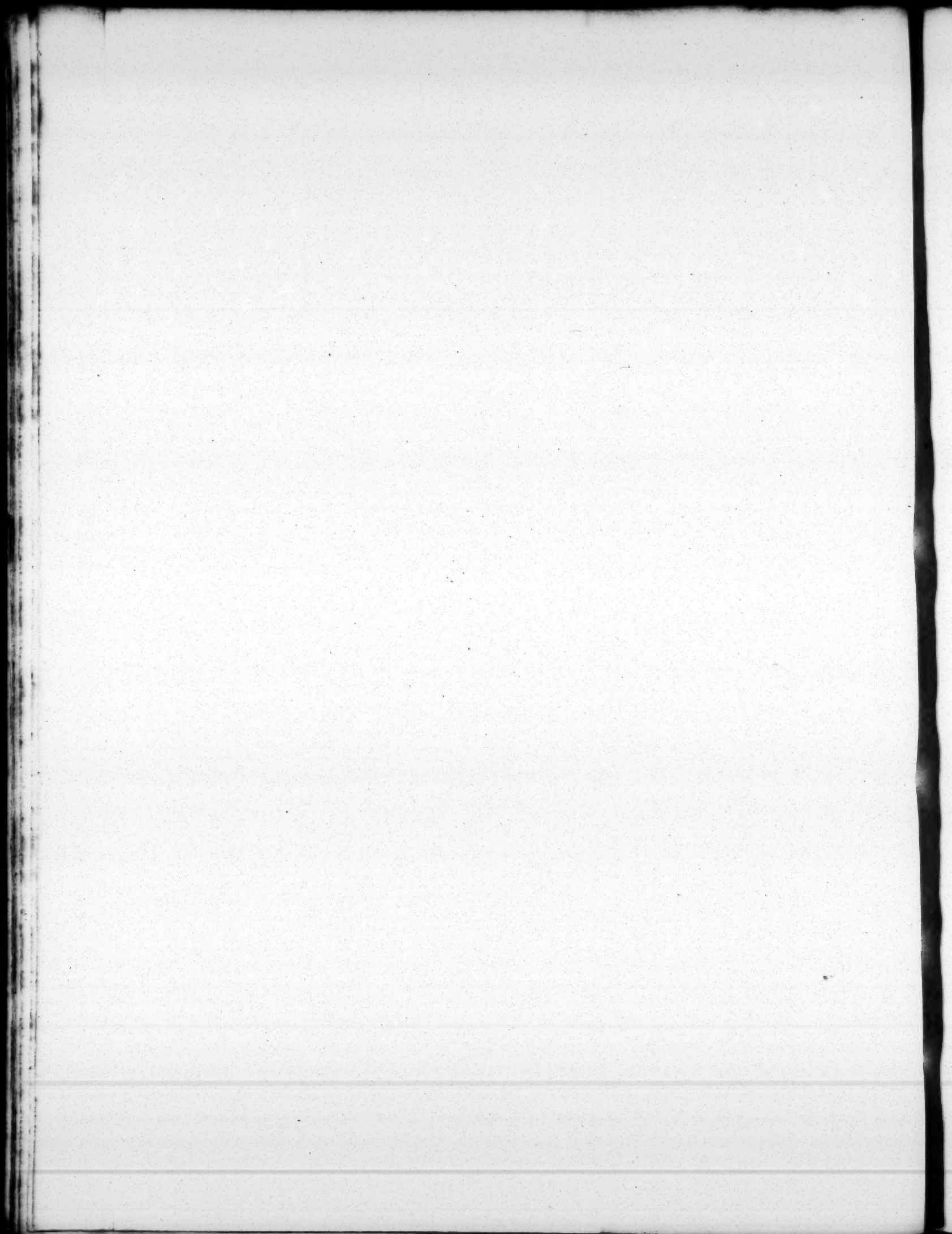
S E C T. I.

THIS noble Fluid, the *Blood*, yields us the most sublime Speculations imaginable, by the Assistance of the *Microscope*. For by the Help of it, *human Blood*, and that of *Land Animals* is found to consist of round red Globules, which float in a transparent Fluid, each of which is compos'd of six smaller, and more transparent ones, and each of these (as Mr. *Leeuwenhoek* has shewn in his 128th *Epistle to the Royal Society*) into six more minute and without Colour. He hath also shewn us how easily six soft flexible Globules, which are compressible into any Shape, and in continual Motion, may, by striking against each other, compose one large Globule of a perfectly spherical Figure, one of which, and five of the smaller Sort, as they appear in Contact, the sixth lying behind, is represented Fig. 29. which, by their mutual Attraction to, and Pressure against each other, readily unite to form a perfectly round Body, as at Fig. 30. Their Attraction towards each other is so considerable, as to form a Kind of fleshy Substance, when brought into Contact; and their specifick * Gravity more than the Serum in which they float.

How these Globules, and also the more minute ones of which they are composed, are occasionally separated, in order to pass through extremely

* *Phil. Transf.* No. 361.





minute Vessels, which without such a Separation, they cannot possibly enter, and how they re-unite again in Vessels where they have more Room, is easily comprehended by a due Consideration of the two foregoing Figures.

The Diameter of a common round Globule of *human Blood*, is equal to the ~~14th~~ 15th Part of an Inch, as by the Method described, Page 27. appears.

In order to view the *Blood* with the *Microscope*, upon the Tip of an Hair Pencil, take a small Drop of *warm Blood*, immediately as it comes from the *Vein*, and spread it as thin as possible upon the Object carrying Glass R, Fig. 2. of the *Universal Microscope*, and apply it between the Object-Plate I, and Springs, to the first and second Magnifiers. It may also be extremely well examined, if a little of it be taken up into a small, but very thin capillary Tube, which being held in the Nippers m of the Apparatus V, Fig. 2. may be readily applied to the Magnifier. If you dilute a Drop of *Blood* with warm Water, and apply it either of these Ways to the Magnifier, some of the larger Globules will be separated from each other, and several of them will be divided into the smaller ones of which they are compos'd.

By either of these Methods, the Globules of the *Blood* may be distinctly seen, and a little Practice will discover any Alteration that may happen in the Colour, Shape, or Size of them; in its several Changes between Sickness and Health. Mixtures of medicinal, or poisonous Liquors, may be blended with it immediately as it comes from the Vein, and a Drop of this Mixture, if applied as before directed to the *Microscope*, will discover what Alterations can be produced on the Contexture of the *Blood*. The Vessel in which the *Blood* is received, should be put into a Basin of Water, somewhat hotter than the *Blood* †, to prevent its coagulating before the Mixture.

The *Circulation* of the *Blood* thro' its Vessels, is to be seen in such small Creatures, whose Transparency permits us to look within them, or in the thinnest Parts of larger ones; by which we are very well informed, the whole animal System being established on the same Plan, the Circulations carried on in Vessels of a like Form, both in the meanest and noblest living Creature, and accelerated or retarded by the same Causes.

In these small Creatures we are not only able to see the general Course of the *Blood*, but can perfectly distinguish each Globule, and the Alteration they suffer in passing out of the larger into the more minute Vessels, many of them being so small, that single Globules can scarce enter, till they are

† The exact *Blood-heat* of the Water, may be obtain'd by a Pocket *Thermometer*, made with *Quicksilver*, with which the Reader may be supplied at my Shop, at *Tycho Brahe's Head* in *Fleet-Street*.

compressed into an oval Form ; and yet these very Vessels are large, when compar'd with the finest of all, in which the Globules must be divided and subdivided into their smallest component Parts, before they can find a Passage.

Providence has been surprizingly careful in the Disposition of the Veins and Arteries, for these last, which convey the *Blood* to the Extremities of the Animal, continually lessen their Diameters in their Progression, and divide into smaller Branches. At which Division, the Globules rush against an Angle, which as it were causes them to recoil upon those immediately behind, before they can readily separate into the two smaller Branches C D, of the Artery A B, Fig. 31. in which the Blood flows upwards from B to A, towards the Extremity ; and on the contrary in its Return back from the Extremities to the Heart, their Diameters increase, and those smaller Vessels are continually uniting into larger, as in the foregoing, Fig. 31. the Branches C and D join their Currents in the Vein E F, till at last all their Streams fall into one, at every such Conjunction of two Branches, as at E, and their Streams violently rush against each other, by which means unnatural Cohesions are prevented.

The Microscope affords us an ample View of the Veins and Arteries, the latter of which is very distinguishable by a Protrusion of the Blood, at each Contraction of the Heart, then a Stop, and then a new Protrusion, continually succeeding each other, whilst in the Veins it rolls on with inexpressible Rapidity.

The ingenious Mr. *Leeuwenhoek* hath told us, that with great Admiration he saw in the utmost Extremities of a very small *Fish's Tail*, how the larger Arteries were divided into the finest Vessels, * and many of the small Veins, which returned from the said Extremities, met together in a larger Vein ; that there was such an Agitation of that *Blood*, which flowed from the larger Arteries, towards the evanescent ones, at the Extremity of the *Tail*, and returned afterwards through many minute Veins into a larger one, as can hardly be conceived : In the larger Arteries he saw a continual new Protrusion of the *Blood's* Course, received from the Heart ; but in the smaller, the Motion seem'd equable without any such repeated Propulsion ; and tho' no Colour appear'd in the minute Vessels, yet in the larger Arteries and Veins, that were near the Extremity of the Tail, the Blood was plainly red.

The exact Magnitude this *Fish* appear'd of to the naked Eye, as delineated by him, is represented in Fig. 32. Its Tail magnified, as it appear'd in the Microscope, at Fig. 33. In which were 17 little *Bones* or *Gristles*, that give a Stiffness to the *Tail*, three of them are shewn by the Letters A B C, on each Side of which he saw a very open Communication

* *Arc. Nat. Tom. IV. p. 167.*

of the Veins and Arteries, the Blood running thro' Arteries, and returning back thro' Veins, which were of the same Size, and evidently a Continuation of the same Vessel, this was distinctly seen in 34 different Places, so that in the Tail of this *small Fish* could plainly be seen 64 *Blood Vessels*, 34 of them Arteries, and as many Veins, besides the little Spaces about D and E, which were not observed.

This will be better understood by a microscopical Representation of Part of one of these little *Gristles* F H G, Fig. 34. on each Side of which runs an Artery I K and M N. The Blood flowing rapidly from I and M, to K and N, their open Communication with the Veins K L, and N O, from whence it return'd to L and O, so that both these were but one continued *Blood Vessel*; for no Vessel can be properly called an Artery beyond the Pulsation; farther than which, and returning towards the Heart, it may be called a Vein; for Veins, as by the present Figure appears, are only Arteries elongated; and as they generally divide into Branches that escape the Sight, it is very difficult to determine where the Arteries end, or where the Veins begin. If in the Tail of this small Fish, the whole Bulk of which was no bigger than that of Fig. 32. and consequently under half an Inch in Length, 34 distinct Circulations of the Blood could be seen, how incredibly numerous must that of the Circulation be in an human Body? Nor is it to be wonder'd at, when we see it issue forth at every Prick of a Pin or Needle. In this Consideration he also adds, that he is fully convinced in a Space no bigger than his fore Finger Nail, a thousand distinct Circulations of the Blood are performed.

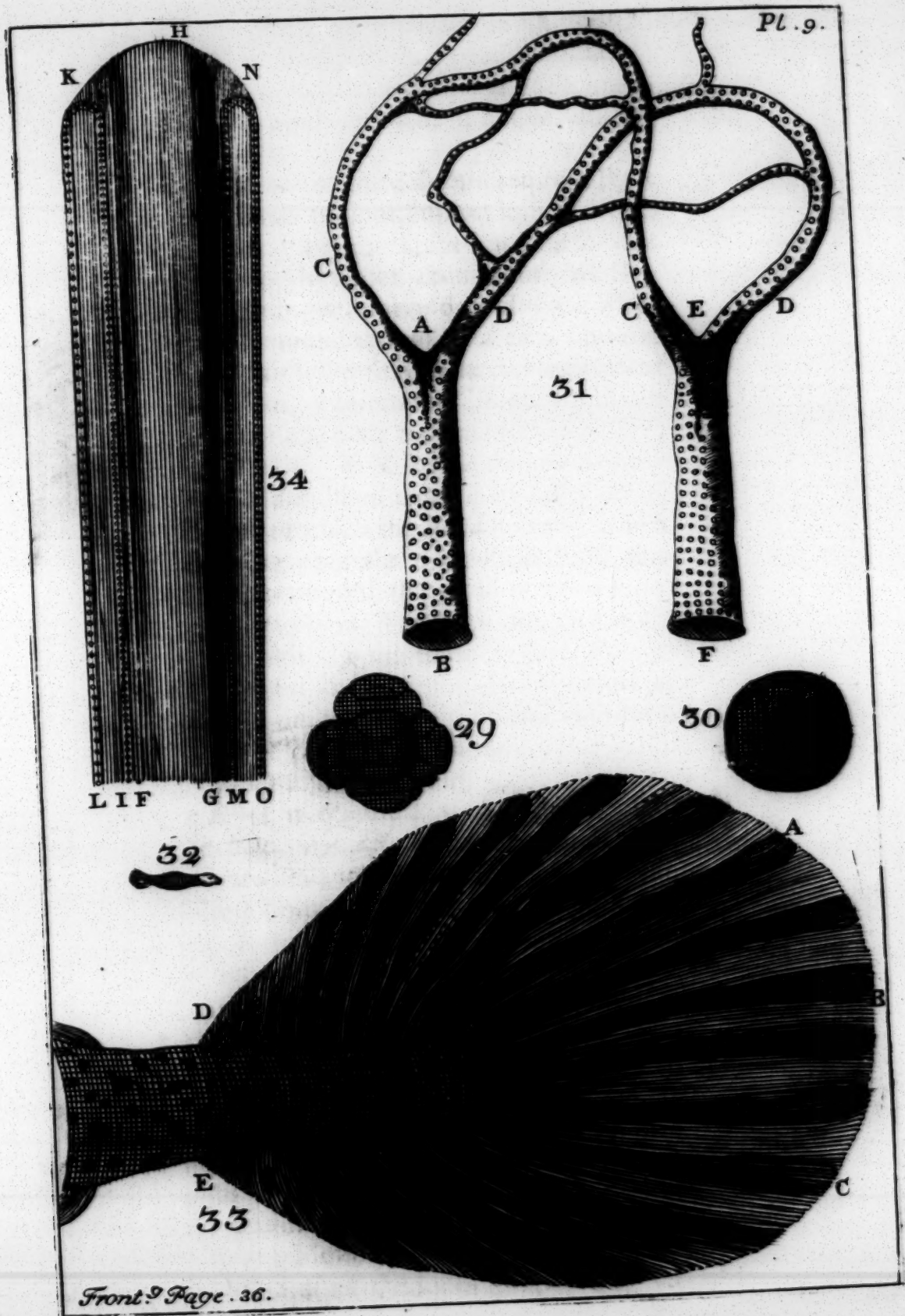
Mr. *Leeuwenhoek* observed the Motion of the *Blood* in a small Vessel, in the Tail of a *Tadpole*, somewhat wider than to admit a red Globule thereof, as A and B, Fig. 35. which Vessel is called an Artery, through which the *Blood* coming from the Heart, in the Direction A, B, is impelled with great Swiftneſs, and divided at B into two Branches, B C and B E, which are again united at D, and continue ſo to F, where they are again divided into two other Branches F G and F I running crooked till they are again united at H, where they formed a ſomewhat larger Vessel as H K, and became bigger at K, for which Reason we muſt call the *Blood Vessels* A B C, D F G, and A B E F I, Arteries, * becauſe they convey the Blood to their greateſt Diſtance from the Heart at G and I, and the *Blood Vessels* G H K, and I H K, Veins, becauſe they return the *Blood* to the Heart again.

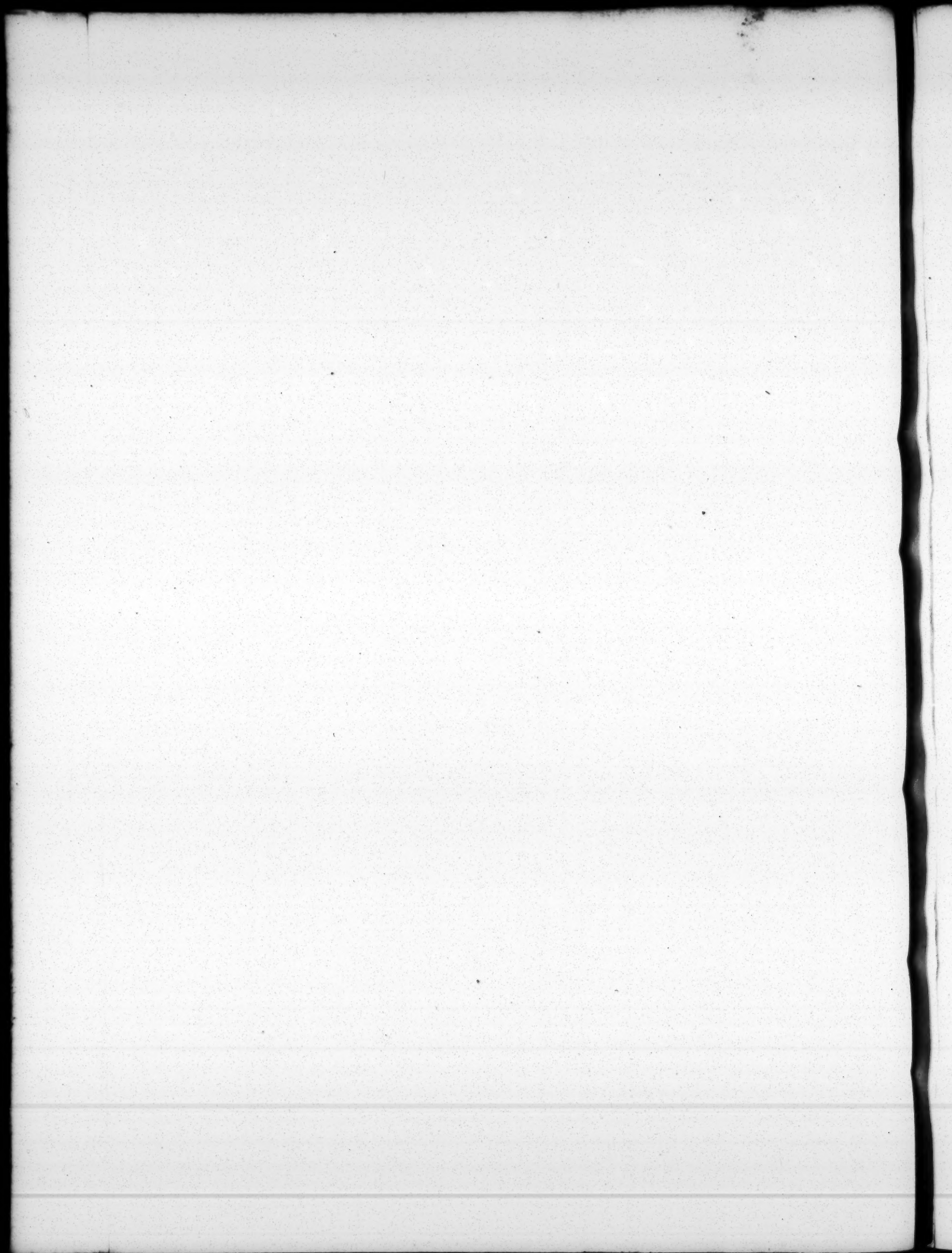
In another Place he ſaw the *Blood* running in an Artery, large enough to admit about 20 red Globules † at once; this was a great Artery in Proportion to that before-mentioned, a ſmall Part of which is delineated at L M, Fig. 36. out of which proceeded a leſſer, as M O. The *Blood* in the Vessel from L to M, had not ſo quick a Motion as it had in others,

* *Arc. Nat. Ep. 119.* † *Phil. Trans. No. 260.*

because the *Blood* in the Vessel at R, did in a Manner stagnate, inasmuch, that no separated Parts could be distinctly seen, it appearing there of one uniform red Colour; yet in the Vessel M O, the *Circulation* was as swift as in any other Vessel. That the blue Spots, occasioned by a Fall or Bruise, is not stagnated *Blood*, which perspires before it begins to corrupt through the Skin with the Sweat, Mr. *Leeuwenboek* was convinced of by the following Observation. The *Blood* at R being thus without the least Motion, it was by every Pulsation of the Heart impelled upward, from N to P, and the next Moment recoiled back again, and this alternately with an undulatory Motion; as is known if never so much Violence be used in pressing Water, yet it cannot be pressed closer than it was before; so the *Blood* being now impelled forwards through the Heart, cannot be compressed into a less Space; this being so, we must conclude, that the Tunick of the *Blood Vessels* between N and P, and also somewhat below N, is distended at every Pulsation of the Heart; and as soon as this uncommon Distention is performed, so soon also does the Tunick of the Vessel contract itself again; whereby the *Blood* that was thus pushed forwards is forced to run back again. After a short Space of Time he saw the *Blood* begin to move from P to R, in such a Manner as to be pushed back again, and that during his Observation, the *Blood Vessel* M O, was a little more extended; consequently more *Blood* ran through it than when he first began to look upon it; the *Blood* in the Vessel N S, wherein was little or no Motion before, now ran as swift as in any other Vessel, the Vessel P Q was so small, that only one single Globule could pass through it at once, wherein not the least Motion, at his first observing it, could be discovered, now began to flow; yet the Particles of *Blood*, which at first passed through it, were but few in Number, and consequently far asunder; henceforward all the *Blood* from P to R was put into Motion, as well by being pushed forward, as by recoiling back again, and that at every Pulsation of the Heart; Mr. *Leeuwenboek* spent about two Minutes in these Observations. From whence it plainly appears, that the stagnant *Blood* can not only be made to move again by the Motion of the Heart, which we call the beating of the Pulse, but also that the coagulated red Globules are again dissolved, and assume their first Figure; from which we may reasonably conclude, that the coagulated *Blood* in any Animal occasioned by a Blow or Bruise, can in a few Days be made to move again; it being taken for granted, that the Heart of a Man pushes out the Blood 75 times in one Minute, which is 4500 in one Hour, and 108000 times in the Space of a Day and Night; and finding that in 10 Days Time the coagulated *Blood* seem'd to vanish, and also considering that in this Time the Heart performs 1080000 Pulsations, and that in each Motion, into several Vessels together, there has been loosen'd and set a-going the Quantity of a Grain of Sand, how much more will be pushed forward in the same Time.

Mr.





Mr. *Leeuwenboek* could see the *Blood* received from the Heart at each Impulse, in the Vessel above-mention'd. If we suppose that the Quantity of a cubick Inch of coagulated *Blood*, occasioned by a Blow, is too much, and that seldom so much is coagulated at once, we may easily conceive, that such coagulated *Blood*, by Means of so many Protrusions as above-mention'd, may be loosen'd, and its Motion again restor'd, if not in all, yet in most of the Vessels.

At another Time Mr. *Leeuwenboek* laid one of these *Tadpoles* upon a Piece of white Paper, a little while before he came to look upon it. A small Part of the Tail was wounded by the Skin sticking to the Paper; so that out of an Artery in the excoriated Part, so large that about four red Globules of the *Blood* might pass through it at once, there flowed some *Blood* that remain'd without Motion about the wounded Part, yet that whereon his Eye was fixed, not being half an Hair's Breadth from the excoriated Artery, there proceeded a Branch of a Vein, wherein the Circulation of the *Blood* did still remain, as if the Artery had not been broken, Fig. 37. T V, exhibits the Artery wounded a little above V. V X shews the *extravasated Blood*. V W, the small Artery wherein the *Blood* retain'd its full Course, altho' it was so near the Artery T V, out of which the *Blood* flowed; which at first seem'd very strange, but observing that the *Blood-Vessel* V W was united at W to a large *Blood Vessel*, that convey'd the *Blood* to the Heart, the *Blood* out of V W was continued as swift as if it had been impelled from T to V, in such a Manner that Mr. *Leeuwenboek* imagined, the Vein at V had not been united with T, but had lain with its Aperture at V, in the *extravasated Blood*; so that the *extravasated Blood* was only for a little sucked up and convey'd thro' it. He then saw a Vein wherein the Motion of the *Blood* seem'd very uncommon, as at Fig. 38. whereof a b represents an Artery, whereby the *Blood* is impelled with great Velocity from a to b, then b c, whereby the *Blood* is conveyed towards the Heart, must be called a Vein, close by which lies another Artery d c e, wherein the *Blood* is conveyed from the Heart from d to c; now if the Vein b c be united with the Artery d e, as is seen at c, and the *Blood* be thus conveyed from c to e, b c should be called a Vein, and the *Blood* coming to c, being there transfused into c e, is the arterial *Blood*, because it is conveyed thither from the Heart, it being certain, that d c e is an Artery.

Amongst others, Mr. *Leeuwenboek* had a *Tadpole*, wherein he could perceive no Motion at all of the *Blood*, how attentively soever he view'd it; at first there appear'd no Reason for it, till upon examining this Animal with his naked Eye, he observed the fore Part of his Body was contracted, by which he imagin'd the Heart was so oppress'd, that it could not force out the *Blood*, and receive it back again. Whilst he was thus contemplating, the Animal made a very strong Motion; beating its Tail about, and bending its Body, by which it got clear of the Oppression it was under;

der; and on viewing it again, perceived the *Blood* to have a slow Motion, and Impulse in several Vessels, which increased till it at length came to its proper Motion, yet not with such Velocity as it would have had, if the Heart or Body had not been oppressed. Mr. *Leeuwenhoek* says, that the Motion of the *Blood* in these *Tadpoles*, exceeds what he ever saw in any other Animal. Fig. 39. exhibits a *Tadpole* arrived to such a Bigness, as to use its hinder Legs, and the fore Legs were also discernable, but yet covered with the Skin.

Mr. *Leeuwenhoek* observed the Circulation of the *Blood* in several *Butts*, one of which, bating the Tail, was but an Inch in Length, the greatest Motion of the *Blood* observable through the Fins, was on each Side the various little single Bones placed therein, where the *Blood-Vessels* were so large, that 25 of those Particles which constitute the *Blood* of a red Colour, could pass in Breadth, but disappear'd as they drew nigh the Extremity of the Fins, small Vessels being all along dispers'd from the Arteries; on one Side of a little Bone, runs an Artery, and on the other a Vein, corresponding thereto; and finding it easy to extend the Tail, he accordingly stretched it in Breadth, equal to what the Fish gives in swimming, that he might the better observe the Motion of the *Blood* in these extended Vessels, and found when the Fish did not move, some of those small Vessels, which before received three Particles in Breadth, being now stretched out with the Tail-fin, which they run a-cross, did not only admit no more than one Particle, but likewise these Particles did not move so fast, as when the Vessels were not extended; and in some Places were at such a Distance, that one or two more might lie in the Intervals, but could not from all this determine, that the Particles were perfectly oval *.

But to trace the Matter further, he took the *Blood* running from a live *Salmon*, † when cut into Pieces, and put it into a Glass Tube, no larger than a small Quill, which in a short Time congealed; but when it became partly fluid again, he put it into a smaller Glass Tube, and having placed it before his Eye in the *Microscope*, the Particles being in Motion, some of them appear'd of a flat oval Figure, and others, which shewed themselves sideways to the Eye, seem'd a little thick, and those whose Sides did not directly face the Eye, seem'd a little broader, without the least Appearance of any globular Form. Mr. *Leeuwenhoek* also put some of the same *Blood* upon a very clean Glass, and where the Particles lay thin, he perceived them oval; nay in several Ovals he discovered Globules, and in some few six Globules.

Fig. 40. A B C D represent the oval Particles of the *Blood* of a *Salmon*, that weighed 30 Pounds; A B, the Particles that appear'd flat and broad, but did not directly face the Eye; those about c were streight be-

* *Arca Nat. Epist.* 128. † *Philos. Transf.* 263.

fore the Eye, and for the most Part a little clear Sort of Light in the Middle, larger in some than others.

Mr. *Leeuwenhoek*, likewise, placed some of the *Blood* of a very small *Butt* before the Microscope, which was not mixed with any Liquor, only the Particles lay in their Serum, and are represented by Fig. 41.

Those Particles of the *Blood*, which are distinguished by shining Spots in the Middle, are delineated Fig. 42. Mr. *Leeuwenhoek* prosecuted this Enquiry yet farther, with a greater Magnifier than he had hitherto used, and so he plainly made out the oval Particles; now the greater the magnifying Power of the Glass, the swifter does the Circulation of the *Blood* appear; and having retarded this Motion, he employed two or three Seconds of Time, in observing the little Veins, and found, that in several small Vessels, the oval Particles were so broke, that he could neither see them, nor those, of which six constituted a Particle of *Blood*, but only a simple Fluid of a faint Colour, running along the Vessels; but in a great Artery at the Tail, the *Blood* mov'd so slowly, that he could easily discern the Particles were oval; and not only so, but he likewise perceived more clearly than before, the Globules that constituted the oval Parts, if not always, yet at least for the most Part, as represented in Fig. 43.

How venous *Blood* may become arterious without being first in the Heart, appears by the following Experiment. Suppose A B, in Fig. 44. to be a Vein, in which the *Blood* view'd thro' the Microscope, passes with great Celerity from B to A, from this Vein proceeds two small Branches, C and D, which unite between E and F. Again suppose H I to be an Artery, in which the *Blood* moves upwards with equal Swiftness from H to I, out of H I arises a venous Spring, delineated in K F L; the *Blood* moving from K to F, joins the other at F; and by this Means, Part of the *Blood* coming from the Artery, is thrown into the Vein, as passing from F to G, and to the best of Mr. *Leeuwenhoek*'s Observation, a Quantity of *Blood*, just equal to that carried from K F to G, moves from C E to F, and directs its Course upwards from F to L, so that whatever Quantity of arterious *Blood* passes thro' K F and F G, an equal Quantity of venous *Blood* returns thro' C E and F L. Though the agreeable Motion of the *Blood* was formerly apparent, yet this Experiment afforded him a very clear Perception of the above-mention'd Variety; and besides, this Union of the *Blood-Vessels* was not formerly discover'd.

Mr. *Leeuwenhoek*, in his 112th *Epist.* has given us an accurate Delineation of the *Blood-Vessels* in Part of the Tail of an *Eel*, whose whole Length did not exceed that of the Length of his little Finger. The Figure, as by him delineated, is represented in Fig. 45. whereof A, C, E, represents the Veins, and B, D, F Arteries.

The Letter D represents an Artery, from which a Branch G proceeds, that is divided about H, into two lesser Branches, one of them represent-
ed

ed by the Letters H I K, so much of this small Vessel as reaches to I, is called an Artery, because the *Blood* may to that Place be propelled in its Progression from the Heart. The other Part I K of the same Branch may be called a Vein, because by it the *Blood* is conveyed back again to the Heart. In the other Part of the same Branch H L M, the *Blood* is drove forwards till it arrives at M, where it is discharged into the Vein E, which in this Figure is the first Place that can take the Name of a Vein.

Here also it may be observed, that as the Arteries are extended in Length, they gradually lessen. And on the contrary, the Veins increase in their Diameters as they approach the Heart.

Furthermore, from this same Artery D, another Vessel may be seen branching out from N, from whence the Blood flows to O, and there discharges itself into the Vein E.

Raise your Eye a little higher to P, where another small Artery advances from the great one D, towards Q, where it closes again with the Vein E.

Also observe that about the Letter R, another small Vessel leads from the same Artery towards S, at which Place the *Blood* that flows both from the Artery D and B, is joined, and from thence pour'd into the Vein C.

Somewhat higher, about T, advances a little *Blood-Vessel*, which is divided into two Branches at V, so that from thence two distinct Vessels may be seen to discharge themselves into the Vein E, at X and h.

About the Letter Y proceeds from the same Artery D, another small Vessel, which at Z branches out into two more minute Vessels; the *Blood* flowing through them toward a and b, where it is discharged into the Vein C.

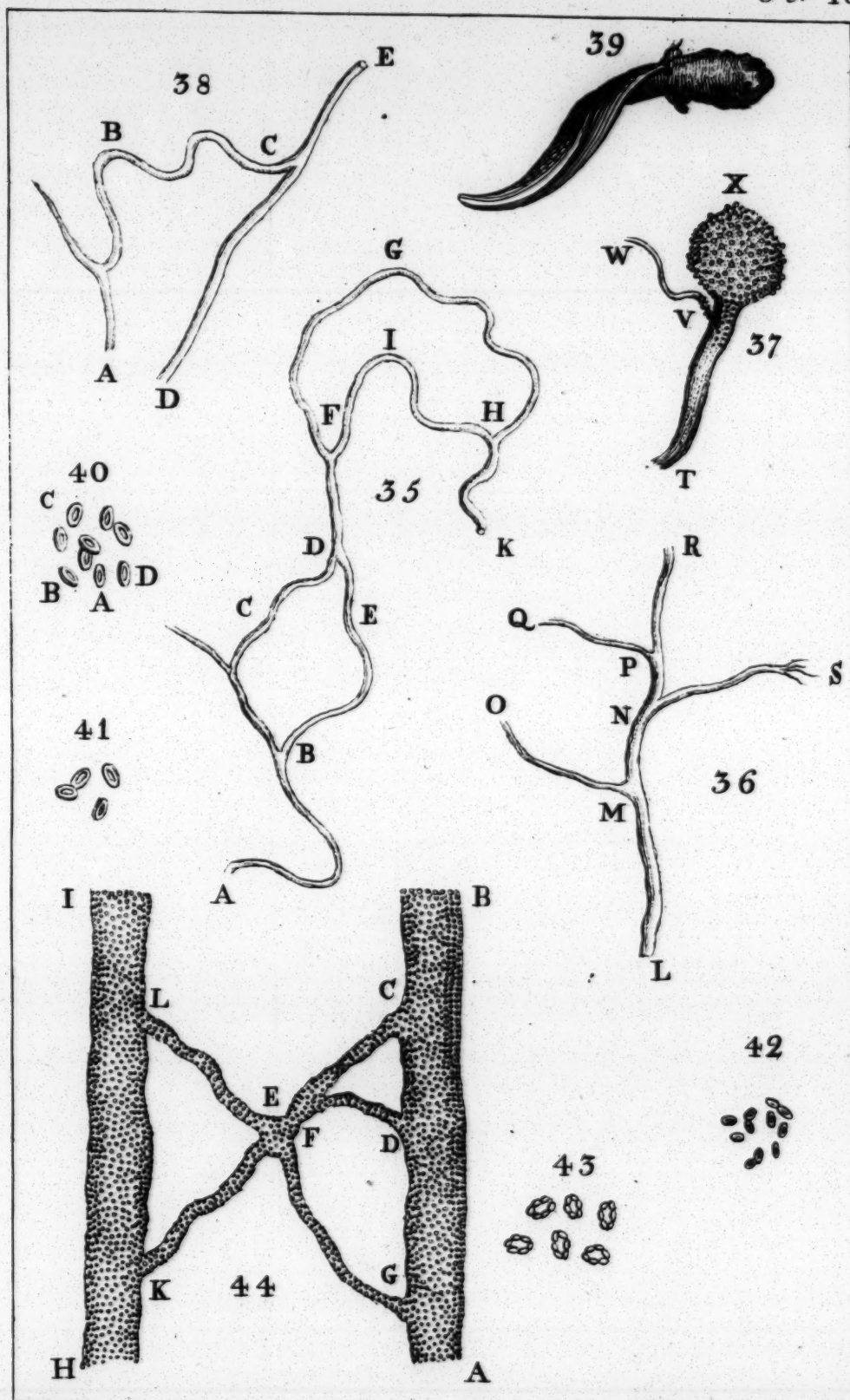
Not far from Y, about c, proceeds a small Branch from the Artery D, through which the *Blood* also returns into the Vein C, with which it joins at d.

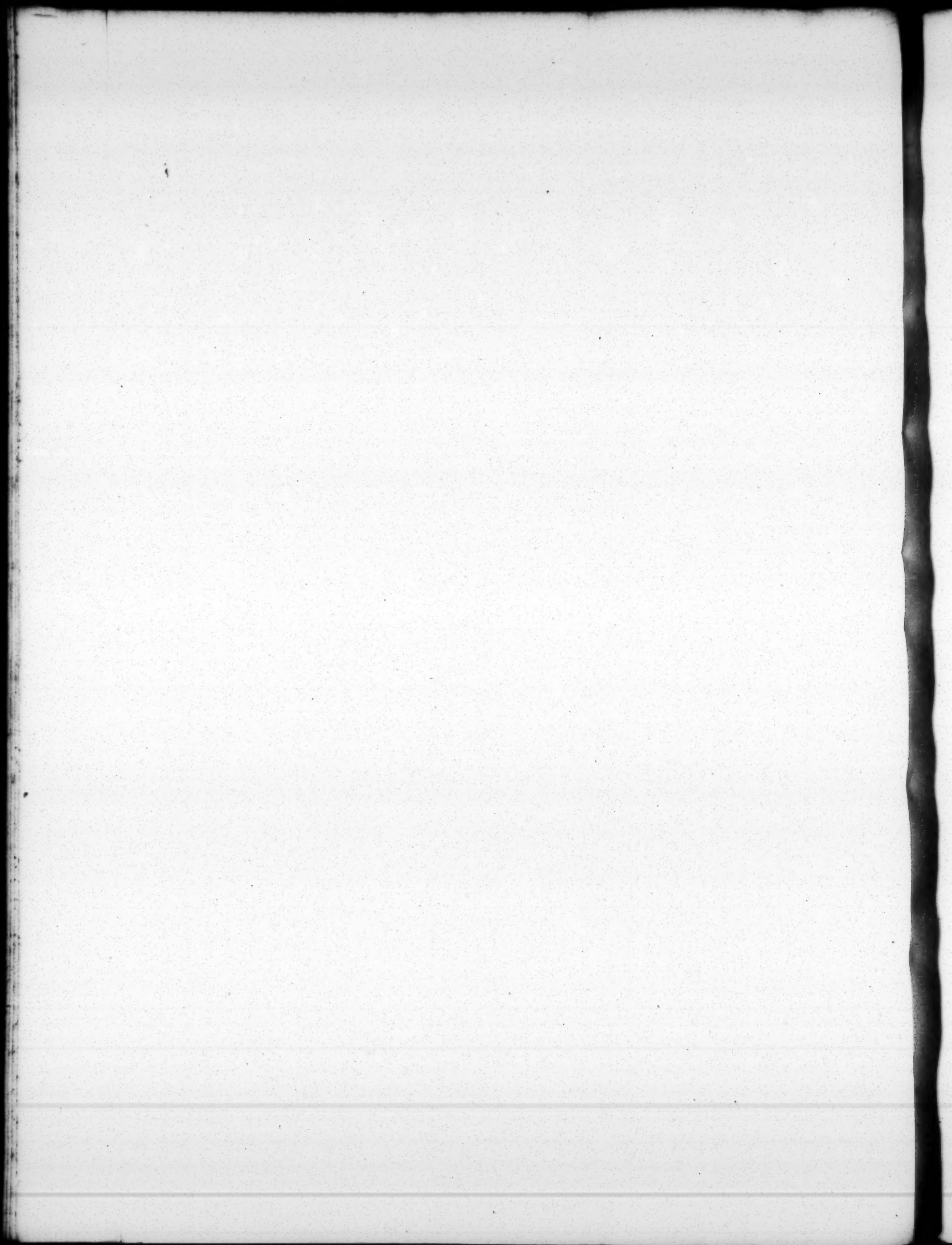
From the same Artery D rises a minute Branch e, f, which is separated into two lesser Branches at f, sending back the *Blood* to the Vein E, at g and h.

If the same Artery be examined a little higher, another Branch I k l, will be seen issuing from I, which is also divided at l into two others, that likewise discharge themselves into the Vein E, at m and n, near I; at o, are also two other Branches, which vent their Streams at p and q, into the Vein C.

Moreover from the same Artery D, about r, proceeds forward a small one r s, which is divided into finer Branches, one of which r s t, joins the Vein C, the other s, u, w, x, joins the Vein E at x.

The most evanescent Artery, flowing from the large one D, which is represented by the Letters r y z, unites with the Vein E at A; the same
minute





minute Artery, near the Letter u, is again divided into two Branches, the Part u b is discharged into the Vein C, at t.

An Eel of this Size may be conveniently placed before the Magnifiers in the *Universal Microscope*, either in the Fish Pan, or in a small Glass Tube filled with Water, and put between the Object Plate and Springs, after wiping off its Slime, which would obscure the Glass, stop both its Ends to prevent the Water from running out; the Tail may then be viewed, and the Circulation will appear in an agreeable and pleasant Manner, as in the foregoing Figure is described.

The Tails of any Sort of small Fish, may be also readily applied to the Magnifiers in the same Manner. Under the Spring of the Fish-Pan a b f, as is before directed in Fig. 2. of Chap. 1. *Flounders*, *Eels*, and *Gudgeons* live a long Time out of Water, and are to be had at almost any Time in *London* alive.

Also the Tail * of a *Water Newt*, or a *Lizard*, if applied to the *Microscope* in a Glass Tube, represents an agreeable Prospect of the Circulation, through Variety of small Vessels, particularly in an exceeding small one of the Water-Kind, which may sometimes be procured shorter than an Inch, and so transparent, that the *Blood* may be seen running in all Directions, not only through the Tail, but particularly in every single Toe, and thro' its Fins or pointed Branches. The *Blood* may be seen running through an Artery towards the Extremity, and returning through a Vein, with which its Communication is very apparent, and surprizingly delightful.

Mr. *Leeuwenboek* informs us, that he has observed the Circulation of the *Blood*, in the farthest Joints of little *Crabs* † hinder Legs, with greater Rapidity than in any other Creature, and that their red Globules were twenty-five times fewer than in any other Land or Water Animal he had before examined.

Exceeding small *Crabs* may be found under Brickbats and Stones, on the Shores of the River *Thames*, when the Tide is out.

The Circulation of the *Blood* may be seen in the Legs and Tails of *Skrumps*, if view'd in Water, wherein you have mixed a little Salt, but in these the *Blood* is not red.

I have frequently seen a Fluid flowing through the filmy Wings of *Grasshoppers*, of a greenish Colour.

The Motion of the *Blood* is also to be seen in the transparent Legs and Feet of small *Spiders*, and in the Legs of very small *Bugs*, and an extraordinary Vibration of the Vessels not discernable in other Creatures.

You may often observe in viewing several of those Objects, the Globules cannot pass through the smaller Vessels, otherwise than single, and then squeezed into an oval Form.

* *Philos. Transf.* No. 288. † *Arc. Nat. Tom. IV. Ep. 84, and 86.*

If a little *Frog's Spawn*, in the Spring Time, be kept a few Days in some of the Ditch-Water, in which it is found, you'll have a great Number of exceeding small *Tadpoles*, which at their first beginning to swim, are nearly transparent, place them before the Microscope in a small Tube, with a little Water, or in a cylindrical Glass, and you may behold the Circulation of the *Blood* in every Part of the Subject, and in a more particular Manner in the Tail, near * fifty Vessels presenting themselves at once to View; and also the Pulsation of the Heart; but they grow so opaque in a Day or two, that the Circulation can then be only seen in the Fins, and at the joining on of the Head, and in the Tail.

The Circulation of the *Blood* affords an entertaining Sight in the thin Membrane between the Toes of the hind Foot of *Frogs*, if well expanded; in the Machine a b f, of Fig. 2. Chap. 1. of the *Universal Microscope*, and being so placed before the Magnifiers as there directed, the Arteries and Veins will be distinctly seen.

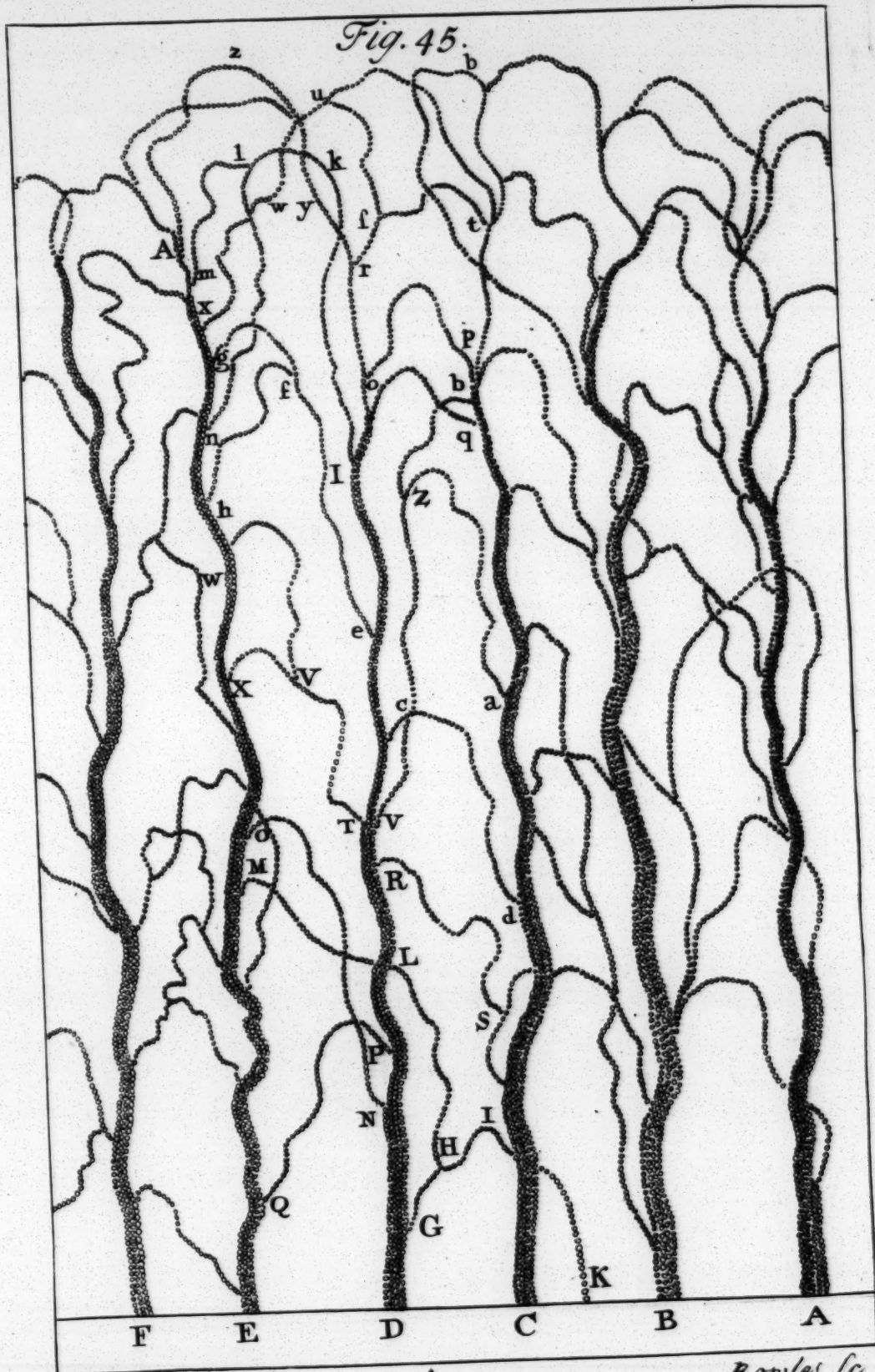
The *Blood* may be retain'd in the Lungs of *Frogs* and *Lizards*, as follows; on making an Incision into the Bodies of these Animals, their Lungs will start out, and be distended with inspired Air; on these as quick as you can, pass a waxed Thread, and tie it firmly towards the upper Part of the Lobe, as near the Heart as possible; when the Lungs are dried, after being thus distended, they may be placed in Parts, between the Talcs of the Ivory Slider T, Fig. 2. and by this Means you may always keep by you, Objects of the Lungs of those Animals, only remember to place their external smooth Surface towards the Magnifier. These several Parts of the Lungs, are very entertaining Objects in the *Microscope*.

But the Circulation of the *Blood* is no where seen with so much Satisfaction as in the Mesentery of a *Frog*. For which I have contrived an easy Method to hold the Animal during the Operation, as will be seen in the following

S E C T. II.

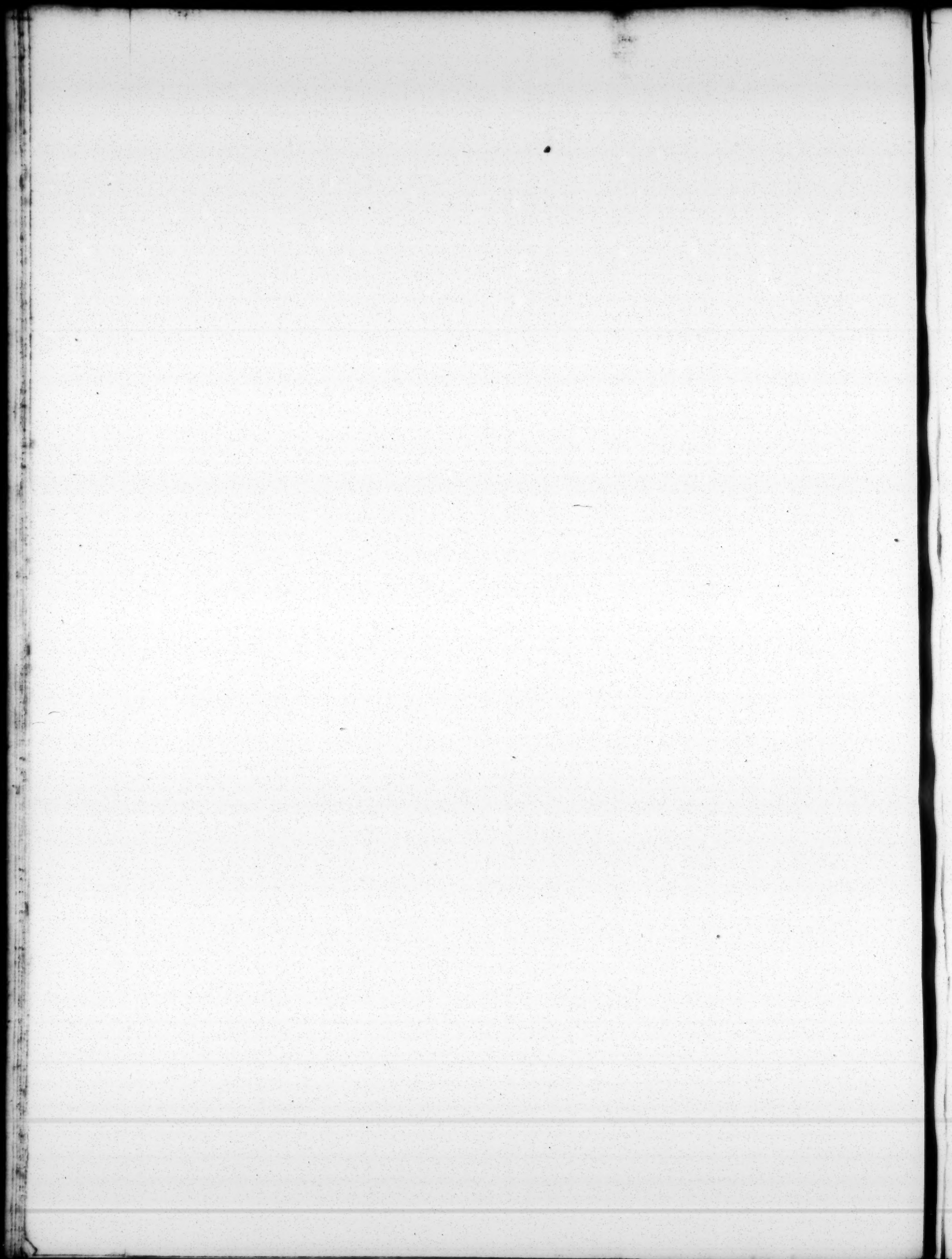
The Description of a New Apparatus for confining Frogs, Mice, Bats, or any other Creatures of the like Size, particularly adapted to the Universal Microscope, Fig. 1.

THIS Apparatus consists of a square Frame of Brass A, B, C, D, Fig. 46. which may be taken to Pieces at Pleasure. It is held together at the Corners, by the four Pillars F, F, F, F, which also support the Frame. At the lower End of the two Pillars which support the Corners C and D of the Frame, is fixed a Steel Bar G H, having one of its



Front. 9 Pag. 42.

Bowles sc.



Ends made fast to one of the Pillars at G, and the other End screwed to the opposite Pillar by the Nut H: On this square Bar is fitted a sliding Socket I K, with its Stem T V.

When a *Frog* is to be dissected, tie a String to each of its four Legs; first having strain'd Strings thro' some of the principal Holes of the Frame, crossing each other, as in the Figure is represented by the small Letters a b, c d, e f, g h, i k, l m, which form a kind of Lattice, or Couch, whereon to extend the *Frog*. Then first put the two Strings which are tied about his Arms, thro' two Holes, the nearest to the Corners A, C, and there fix them with two Pegs made of Fur, as at n and o, in the Figure. The Reason why I direct his two fore Legs or Arms to be fastened first is, because you may with Ease hold his hind Legs in your Hand, till the fore Legs are pegg'd down fast; whereas if you attempt to fix the hind Legs first, the Creature will give such Springs and Starts, as will not only tire himself, and thereby prevent him from being able to go thro' the Operation, but even make it almost impossible for you to fix him to your Mind. Then fix his hind Legs as before directed by the Pegs p, q. If now you find him not quite fast, you may make him so, by pulling out one of the Pegs at a Time, and straining the String a little tighter, after which replace the Peg. The Ends of the Strings which confine his Arms and Legs, are represented in the Figure by the Letters r, s, t, v, and the *Frog* lying upon his Back.

The Object being thus extended, and fastened on the Frame, as above directed, open the Skin of the Belly, from near the Anus to the Throat in the Direction of the dotted Line I K, by first just entering the Point of a very sharp Penknife at I, thro' the first Skin only, taking Care not to touch the second Skin, and let the Incision be no longer than the little streight Stroke I w, in which thrust the Probe or Director, Fig. 47. almost up to his Throat, with the Curf x y upwards, in which Curf you may run the Point of a Pair of Scissars, without being in any Danger of cutting any other Part of the Subject, and thereby open the upper Skin from I to K, then turn the Director sideways from K to L, and from I to M, and give it a little Snip in that Direction, both at the Top and Bottom. Stick a Fish-Hook, with the Barbs filed off, into each Corner of the Skin, first having put the Strings N O, to which the Hooks are tied, through any two of the Holes in the Frame, as at P and Q. Then by gently pulling the Strings N O, the Skin will readily stretch out into the Direction of a square Flap, as represented in the Figure by the Letters L M R S, and the three dotted Lines which surround them.

If now you put the Stem T V into the Hole of the Pillar E of the *Universal Microscope*, you may place any Part of this Flap before the Magnifiers, either by slipping the square Steel Bar G H backwards and forwards in its sliding Socket I K, or else by pulling the said Socket farther from, or

pushing it nearer to the upright Pillar E of the *Microscope*, Fig. 1. by which Means, you may with the greatest Ease imaginable, examine all the *Blood-Vessels* in this transparent Flap or Piece of Skin, by sitting at a Table before a Window, and directing the illuminating Glass, so as to fling the Rays of Light immediately under this Part of the Skin.

If the Sun shines, and you have the solar Apparatus, describ'd Page 9. screw'd ready in the Window Shutter, take out the illuminating Glass F, and in its Stead, screw the Socket K, of the solar Apparatus, and apply the *Microscope* and *Frog* to the solar Part as before shewn, and after having directed the Sun's Rays thro' the Tube, upon any Part of the skinny Flap L R S M, and placed the Screen at about four or five Foot from the Machine, so as to receive the Sun's Rays, and adjusted the Object to the Focus of the Magnifier, and Distance of the Screen, by Help of the Screw P, as in Fig. 1.

You will have represented on the Screen, a most beautiful Picture of the Veins and Arteries in the Skin, with the *Blood* circulating thro' them; in the Arteries you may plainly perceive the *Blood* stopping, and as it were receding a little at each Dilatation of the Heart, and then immediately rushing forwards again at each Contraction; whilst in the Veins it rolls on in a continual Current, with inexpressible Rapidity; and when the Arteries are very much magnified, if you remove the Screen to a considerable Distance, the alternate Expansion and Contraction of their Sides are very visible.

When you have consider'd this as long as you think needful, open the Abdomen, and extend the Muscles before the *Microscope*, by Means of the two Fish-Hooks, as before in the Extension of the Skin, and you will with Pleasure view their Structure, which consists of Numbers of transparent Strings or Fibres, lying parallel to one another, and joined together by a common Membrane.

These Strings or Fibres appear thro' their whole Length, to be made up of minute roundish Vesicles; and the *Blood Vessels* which intermix with them, afford an agreeable Prospect.

The next Experiment is gently to draw out a Part of the Frog's Gut, in order to apply the Mesentery to the *Microscope*, which is a most beautiful and surprizing Phenomena, when view'd through the *Universal Microscope*, as standing upon a Table: But when applied to the solar Apparatus before described, you may view it in so distinct and fine a Manner, that no Words can describe the wonderful Scene which will then be presented to your Sight. The *Blood* flowing through numberless Vessels at one and the same Instant, in some one Way, in others the quite contrary; several of the Vessels may be magnified to an Inch in Diameter, and the *Blood* Globules rolling thro' them, will appear near as large as Pepper-Corns, and at the same Time in the minutest Vessels, only single Globules can find a Passage, and that not without putting on the Form of oblong Sphere-

Spheroïds; here also in the most inexpressible Manner, will be seen the Pulsation and Acceleration of the *Blood* in the Arteries, as before described.

As the *Animal* grows languid, and near expiring, the *Blood* in the Arteries will be seen to stop suddenly, and as it were seem to coagulate, and then run backwards for some Time; after which it will again recover its natural Course, with a great deal of Rapidity.

A due Consideration of these Appearances, may possibly account for the Intermissions, Starts, and Irregularities in the Pulse of Persons near the Point of Death.

Fig. 48. M, L, R, S, represents a microscopick Picture of a Part of the *Frog's Gut*, and *Mesentery* extended, by Means of the Fish Hooks R, S, M, the Ends of their Strings being pegg'd to the square Frame, one of which is seen at p. B, I, K, C, is a Part of the Body of the Frog. And I, K, that Part where the Belly was opened. D, E, Part of the square Brass Frame. The shaded Part within the Gut, marked M, L, R, S, is called the *Mesentery*, in which is plainly seen the *Blood-Vessels*. Those Vessels, which are a little darker than the rest, are called Arteries. In every one of which I plainly saw a Pulse, and the *Blood* flowing from A to R. The others are Veins, thro' which the *Blood* flowed in a constant Stream, in the Direction V, N.

As there are many small *Fish*, whose Fins are more transparent than their Tails; I thought it might be acceptable in this Place, to give a Cut of the Manner how they may be fastened upon the same Frame the *Frog* was, which take as follows,

First cut a Piece of Leather in the Shape of Fig. 49. and tie a String to each Corner of it, as at A, B, C, D, and observe, that the Part G H of the Leather be no longer than from the *Fish's Neck* to the Part where the Tail begins to grow small, and cut a Slit from A to I, and from B to K, then put the String C E through the Slit A I, and the String D F thro' the Slit B K, and put the *Fish* in Head foremost; after which draw the Strings close, and apply it to the Frame, Fig. 50. fixing down the String D F to the Frame by the Peg N, and the String B M by the Peg O. The String C E may be made fast with the Peg P, and the String A L with the Peg Q, in which Position the *Fish* cannot possibly get away, but on the contrary will lie exceeding quiet: Then may you stick a Fish-Hook to the thick Part of its Fin at R, and stretch it out by drawing the String R S gently, and then making it fast by the Peg T.

After which place the Frame to the *Microscope*, as above directed; and you will have a beautiful Prospect of the Circulation, if viewed thro' the Eye Piece N upon a Table; but much more so if you apply it to the solar Apparatus.

I hope by this Time the Reader will be enabled to fix any other Subject of the like Size to this Apparatus, in order for Dissection, and also be ready

at

at applying them to the Microscope, either to be look'd at by the Eye through the Magnifiers, or cast upon a Screen when applied to the solar Apparatus. The Reader will also perceive that none of the modern Microscopes, is so capable of having all Sorts of Subjects applied to them, as this is, and that in one Apparatus; and so easy in its Use, as to give Gentlemen as little Trouble as possible in the Application of all Sorts of Objects.

C H A P. XII.

Of Bones.

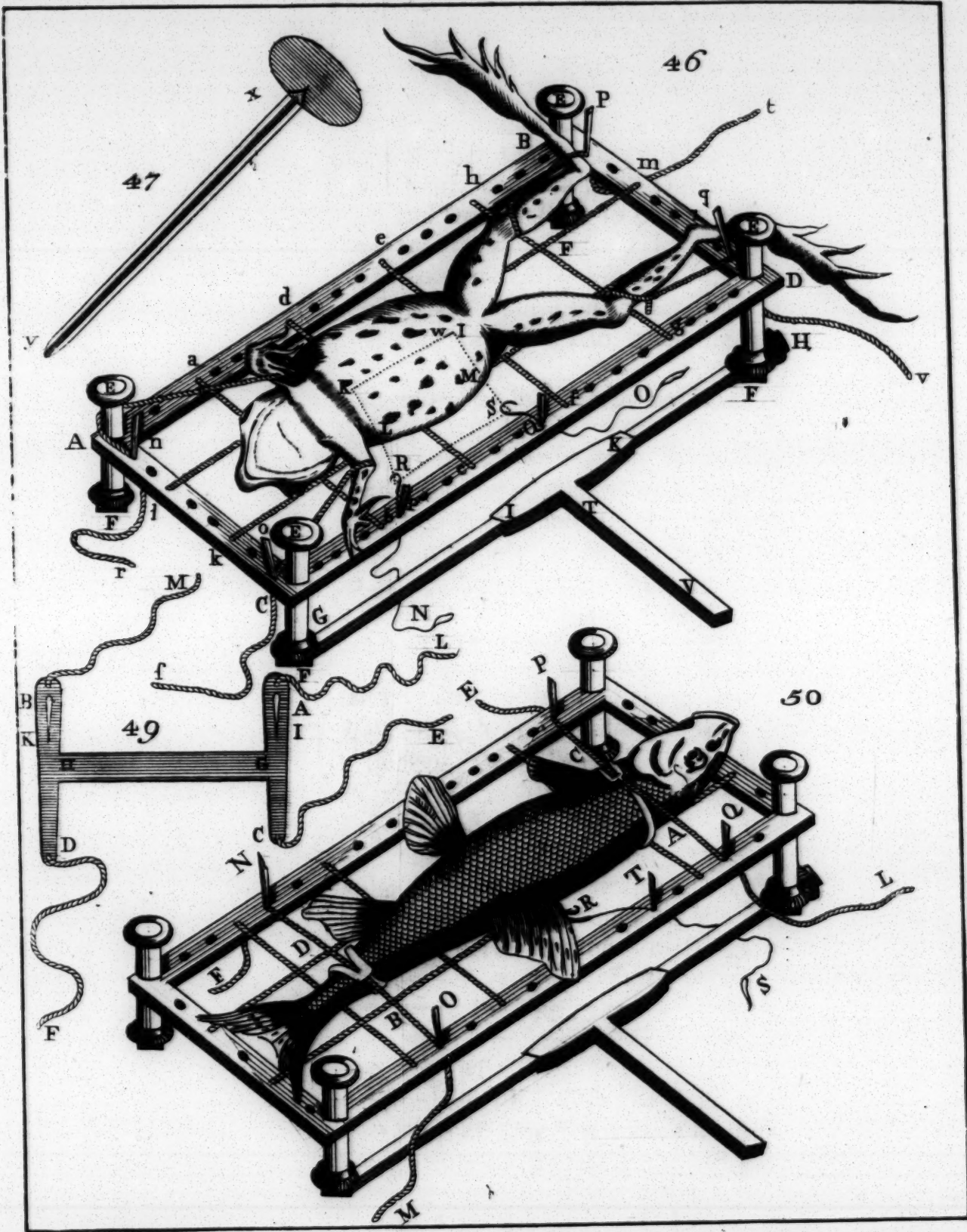
THEIR superficial Part is found to consist of a vast many small Vessels, and some few of a larger Size; which last, when they came to the Surface of the Bone, appeared to Mr. *Leeuwenhoeck* either with a Membrane, or *bony* Substance, perfectly transparent: He once discovered four or five Vessels in a small Piece of a Shin Bone of a sufficient Size for a single Filament of Silk to pass through them, and one of them seemed to him to have a Valve * so disposed as to admit nothing into it, but only to let out what was therein contained.

The spongy or cellular Substance on the Inside of the Bone, consists of long Particles closely united, that are made up of a vast many small Vessels, some running lengthways, others tending towards the Sides of the Bony Particles, some lying parallel, and others perpendicular to the Length of the Bone, these last have Vessels proceeding from their Extremities; and others that compose the Cortex or superficial Part of the Bone, proceed from their Sides, those long Particles, which lie parallel to the Length of the Bone, emit Vessels from their Sides, that issue out through the Side of the Bone. It is impossible to conceive what a prodigious Number of small Vessels compose the cortical Part of the Bone, which on the spongy Part in some Places is no thicker than a human Hair; tho', in others, three or four times that Thickness.

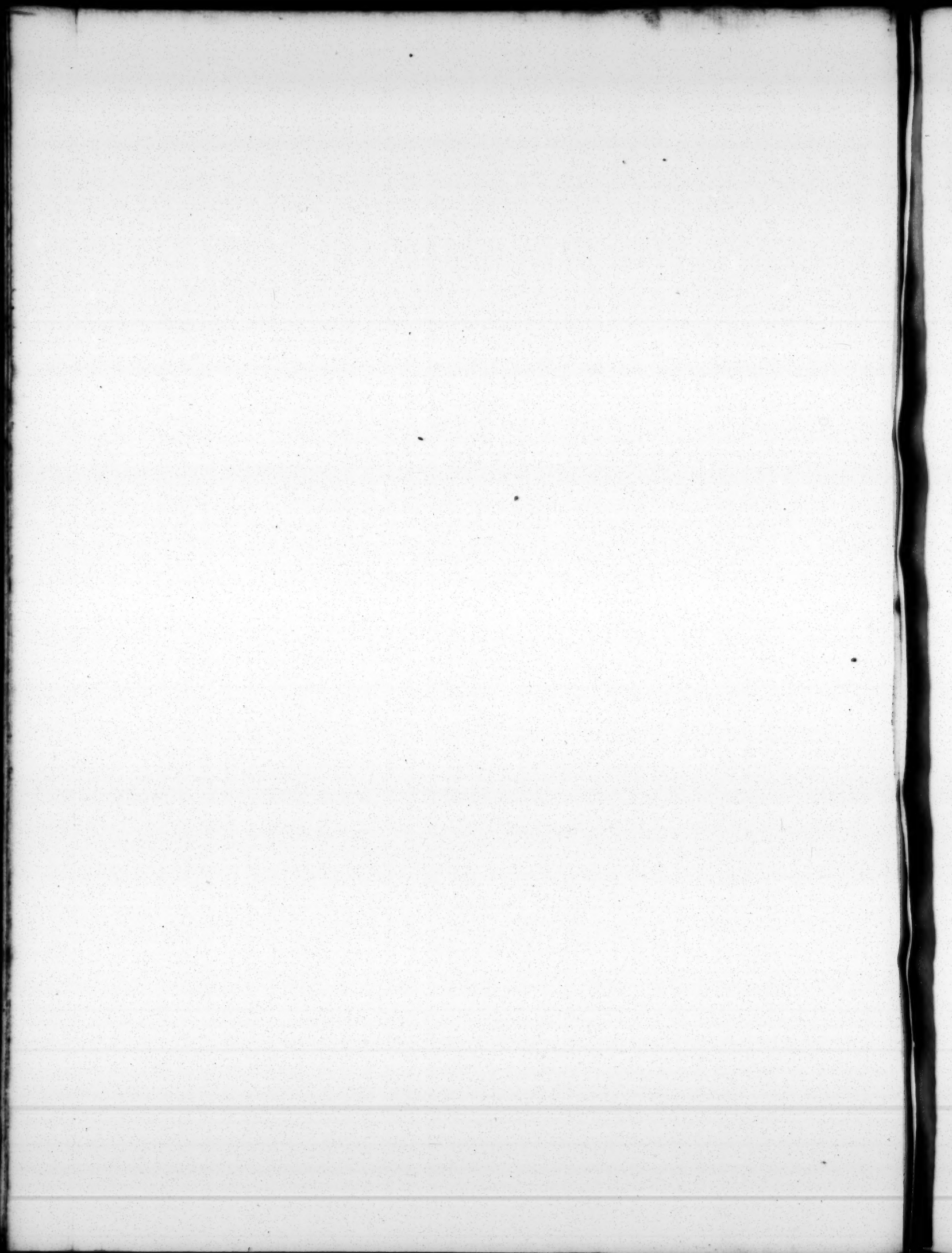
The *Periosteum* is united to the Cortex of the Bone, not only to the Outside of the Cortex, but even by entering into its very Substance in several Places, and is joined thereto by the Vessels which proceed from the Bone.

Fig. 51. represents a small part of the Bone with the Periosteum adhering to it; ABCDEF shews the Bony Part, BGHIE the Periosteum, in which all the small Vessels are represented by Dots. In other Places where the Thickness was twice as much, not only those Vessels that had been transversely cut, and consequently represented by so many Points;

* *Phil. Transact.* No. 366.



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but also many other Vessels running lengthways, as in Fig. 52. L O P Q N M and that Part represented by B G H I E, Fig. 51. are not entirely membranous, but really *bony*. K L M N A represent the *bony* Part, in which tho' no Pores or Vessels are here represented, yet it is full of Openings. Fig. 53. R S W X T V represents a Part of another *Bone*, S W X T the *Periosteum*, which in this Place was no thicker than a large Hair of a Man's Beard; but in another Part of the same, and at a small Distance, it was four times that Thickness. In another Piece of *Bone* so placed before the *Microscope* as to shew only the *Periosteum* and *muscular Fibres*, which were cut transversly, and appeared to be surrounded by Fibrils of the *Periosteum*, as in Fig. 54. where Y Z A B is the *Periosteum*, and Z C D A are the fleshy *Fibres* cut transversly, this was part of a Rib taken from a fat Ox.

It appears therefore from Mr. *Leeuwenhoeck's* Observation on *Bones* of all Kinds, that they do consist of exceeding small Vessels, arising from the inner hollow or spongy Part of the *Bone*, and passing thro' the superficial or cortical Substance, enter the *Periosteum*; and from thence are continued farther into the Body, even to the remote Parts thereof. Hence it is, that in a healthful Body there is a constant Supply of an oily Substance conveyed into the *Bones*; which again is constantly carried out from the *Bones* by Means of these Vessels into all Parts of the Body, even to the Extremity of the Fingers. He examined a very small Piece of the solid Part of the *Shin Bone* of an *Ox*, and found it to consist of four Sorts of Tubes, perforated lengthways. The first Sort so small and so closely united, as scarce to be discernable in a transverse Section of it. The second Sort of Tubes (some of which are four, some six times larger than the first) are also difficult to be discover'd; because in cutting or shaving the *Bone*, although the Knife was sharp, it destroyed and broke many of the tubular Parts, which shut up their Apertures. The third Sort greatly exceed those of the second, but were also difficult to be discerned, because the Knife tore some of them in cutting; yet notwithstanding he was persuaded, that *Bones* are composed out of successive Additions of Rings of Tubes, in the same Manner as Wood is. The fourth Sort are much larger than these, and fewer, as will appear in Fig. 62. whereof M represents a very small Piece of a *Shin Bone*, which when viewed by the naked Eye, appeared no bigger than the Spot, Fig. M.

A B C D is the same Piece of *Bone* magnified, E F G is the Point of a very small Needle, upon which this little Piece of *Bone* * was stuck for Examination before the *Microscope*, he was not able to represent the first Sort of these little Tubes in the Picture, because their Surface was so mangled in cutting, but the second Sort is represented by the Letters H H H, the

* *Arc. Nat. Tom. I. p. 200.*

third Sort by the Letters I I I, which are seldom circular, but of different Shapes, like the great Vessels in Wood. The fourth Sort are a great deal larger, as shewn by the Letters K K. The curved Lines L and M are little Clefts or Cracks made by the Knife in Cutting.

To examine the *Bones*, shave off with a very sharp Razor thin Pieces of them crossways, lengthways, and obliquely, and that from the Inside, Outside, and Middle of the Bone: Then apply to the Microscope some of these Shavings dry, and others moistened with warm Water, by which Means you may view the Vesicles in all Directions. Or put the Bones in a clear Fire till they are red hot; then carefully taking them out, you will find the bony Cells perfect and entire, and being quite empty, may be view'd with great Ease and Pleasure.

They may be applied to the *Universal Microscope*, Fig. 1. either upon the Glass R, Fig. 2. or stuck upon the Point of a very small Needle, which Needle may be held between the Nippers m of the Apparatus V, Fig. 2. and thereby examined with Ease, and little Bits thereof may be preserved between the Talcs in an Ivory Slider, or in one of the circular Talc Rings.

C H A P. XIII.

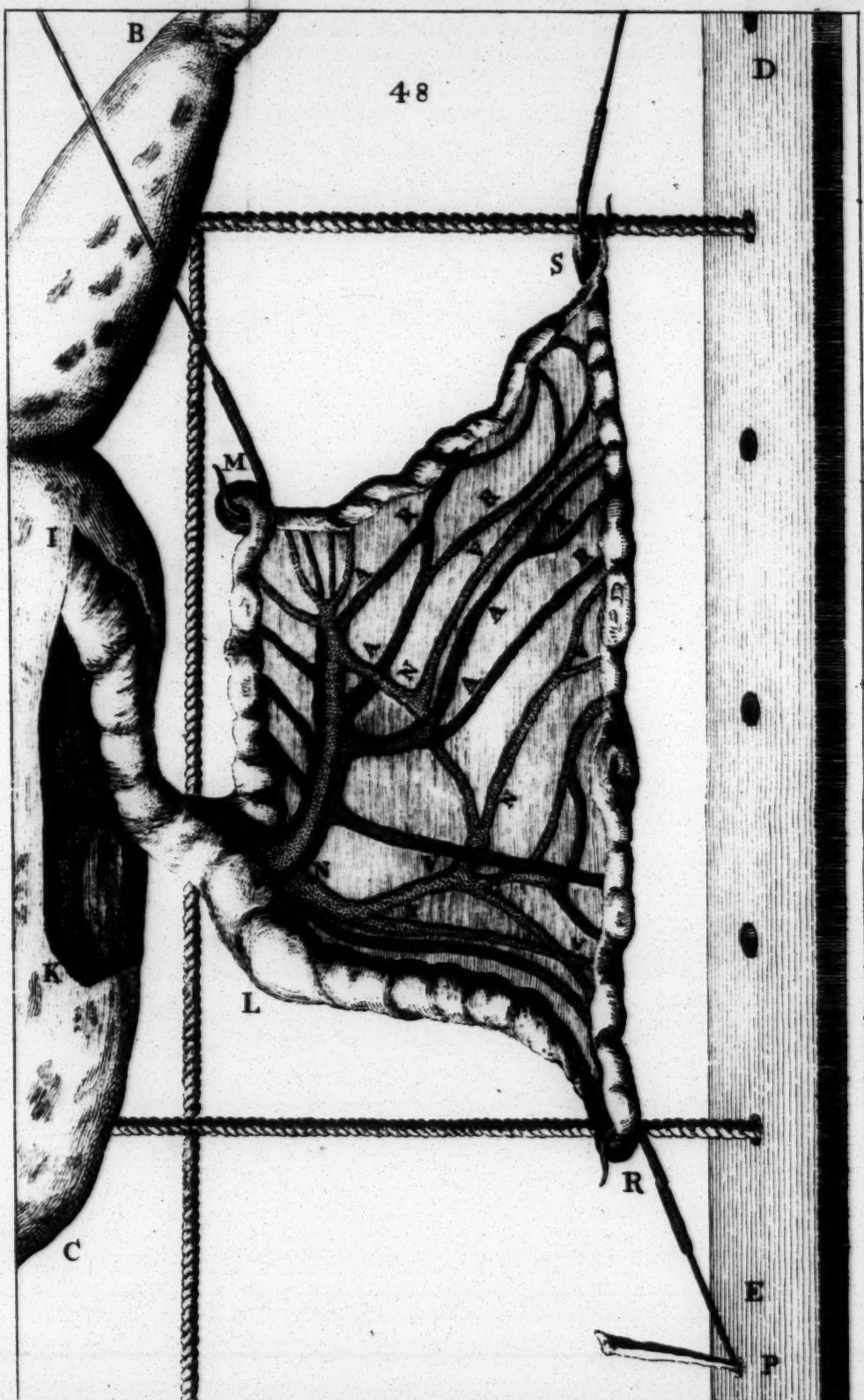
Of the Muscular or Fleshy Fibres of Animals.

MR. *Leeuwenhoeck* hath discovered each muscular Fibre to be made up of smaller *Fibrils*, which, notwithstanding their Smallness, he plainly discern'd to be vascular, for on cutting a-cross their Length, the Light might be seen thro' their Apertures; but if he cut them ever so little obliquely, could see no Light. He also observed the Structure of the *Fibres* in the Flesh of an *Ox*, and of a *Whale*, but plainer in that of a *Whale*; the *Fibres* of the other being more compact and close, and found also that the *Fibres* of a *Mouse* were of the same Size as * those of an *Ox*, from whence he concludes, the different Size of *Animals* is entirely owing to the Number and Length of their *Fibres*. These fleshy *Fibres* appear throughout their whole Length, to be encompassed as it were with spiral Circumvolution, as is exactly represented in Fig. 69.

Which Disposition seems to be wonderfully contrived for Readiness in the Distension and Contraction of the *Fibres*. Two of those *fleshy Fibres* are represented by G H, and I K, Fig. 68.

To view the muscular *Fibres* with the Microscope, cut off a Piece of dried Flesh or Fish, as thin as possible, and lay it upon the Glass R, of

* *Arc. Nat. Tom. III. p. 108.*



J. Wigley. Sc.

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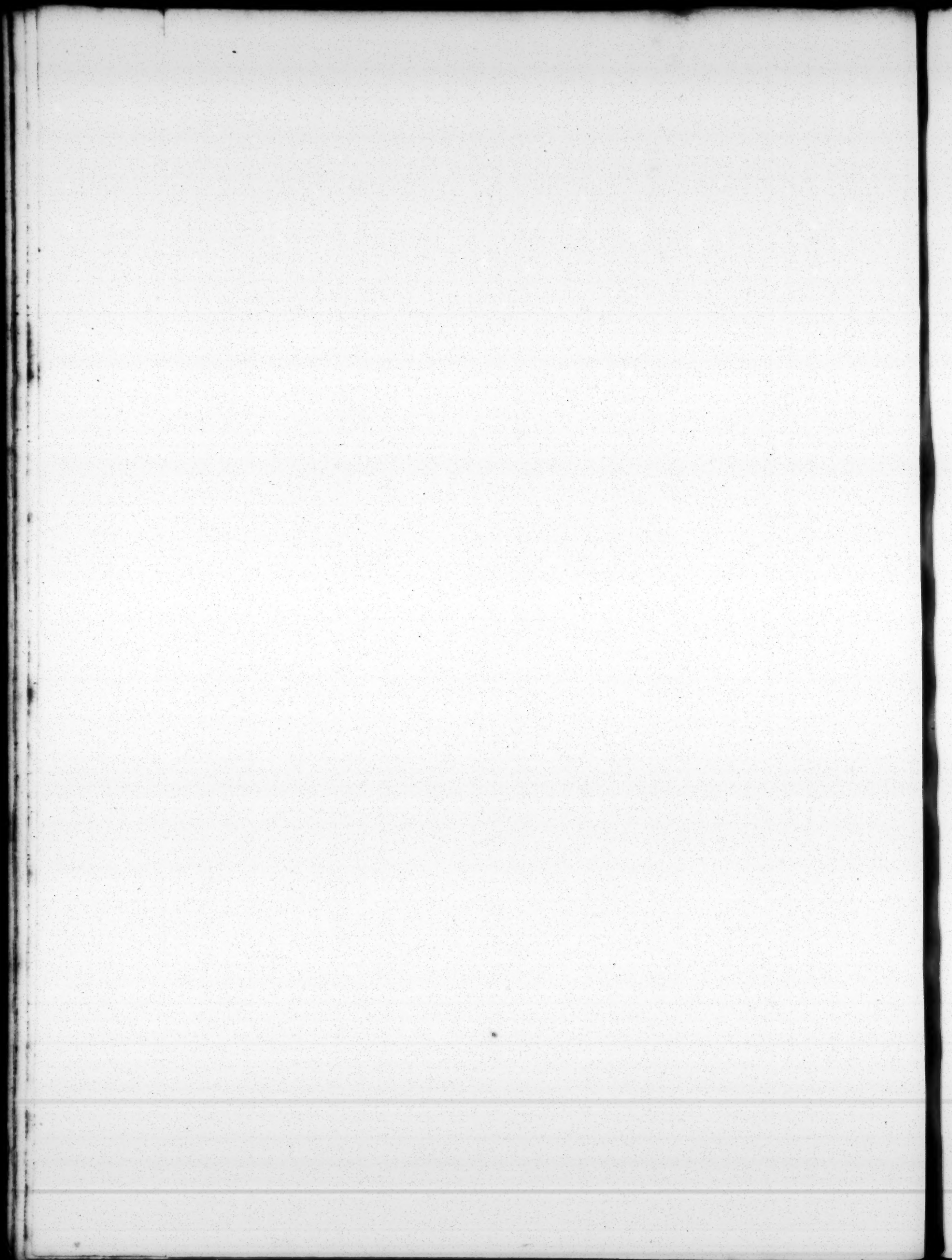


Fig. 2. and moisten it with warm Water, which drying soon away, will leave the Vessels open and distinguishable. As the Learned differ in their Opinions with Respect to the Figure and Structure of these little Vesicles, I shall leave it to the Curious for farther Examination.

Mr. *Leeuwenhoek* informs us, that the fleshy Fibres in Insects are no less visible than those of larger Creatures, which he found by cutting off the Legs of *Flies*, *Gnats*, *Ants*, &c. in all which he could plainly distinguish the circular Wrinkles or Circumvolutions encompassing the Fibres, as in Fig. 69.

Upon cutting the fleshy *Fibres* of a *Whale*, length-wise, and a-cross, † he plainly discovered each Particle, or fleshy *Fibre*, to be enveloped in a fine thin Membrane. It appear'd in the Microscope, as represented Fig. 55. in which the Parts lay so close together, that their encompassing Membranes, represented by the black Lines, were but just discernable; some however appear'd larger than others, and these, ‡ if attentively view'd, seem'd to be divided into a great many others, some also cut transversely, and crowded so close together, that their Figure, as well as Size, was very different. Fig. 56, represents a thin Slice of the Flesh of a *Whale*, which after having been made thoroughly wet, and applied to the Microscope, appear'd as in the Figure. Upon letting the Moisture evaporate from these Slices, the Particles became much smaller, and the Membranes, with which each was encompassed, were very visible. Fig. 57. represents a Piece of the same Flesh, wherein the Particles seem'd to touch, but on their being dried, shrunk up, from the surrounding Membranes, whereas the Membranes themselves could not shrink, because they were all join'd together. All along these fleshy *Fibres* § run Membranes about the Thickness of an Hair, and Distance of a Grain of Sand; from these larger Membranes, other Parts were spread, dividing each *Fibre* into a great many *Fibrils*; from whence we may say, that each fleshy *Fibre*, no bigger than an Hair, is a small Muscle encompassed with its peculiar Coat or Membrane. Fig. 58. represents a small Piece of these *Fibres* greatly magnified; on moistening again the *Fibres* represented by the two last Figures (that were dried and shrivell'd up) they became so distended, as to fill up the Spaces between the Membranes, and re-assume the Shape they had before they were dried. Among several little Pieces of Flesh, moisten'd as above, and placed before the Microscope, there was one, whose Particles were not separated upon drying; suppos'd to be owing to the splitting and tearing † asunder of a large Membrane, which run thro' its Middle, as represented in Fig. 59. by Q R S T V W, where between S T and V, the dried Particles remain unseparated, S W shews the thick Membrane that divided this Piece about

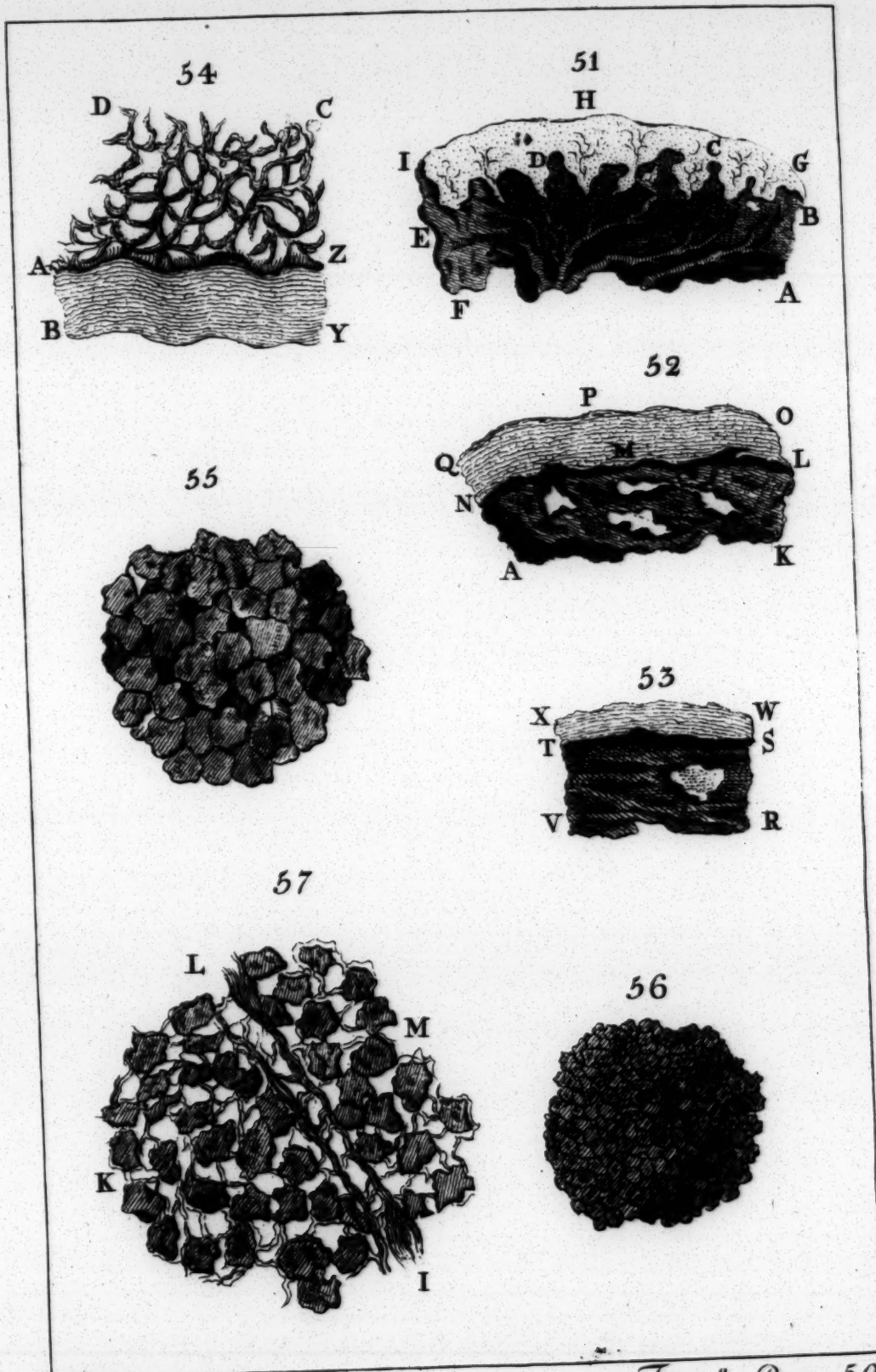
† *Epist. Phys.* p. 3. § *Ibid.* p. 4. ‡ *Phil. Transf.* No. 39.

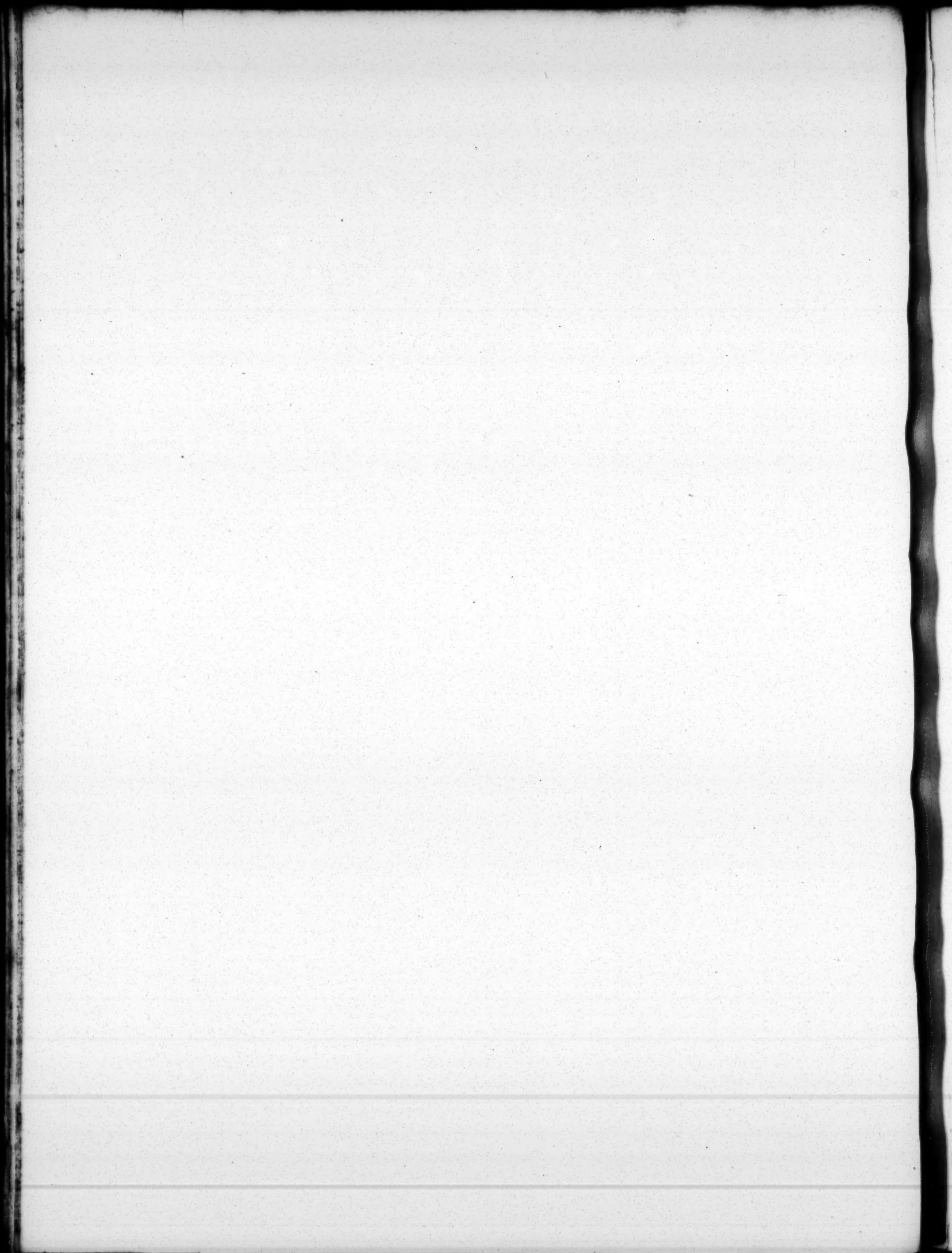
the Thickness of an Hair, that sent out a Branch at T, and at W was split into two. Fig. 60. represents a very small Piece, consisting only of five *Fibres* cut lengthwise, as they appear'd thro' the Microscope; between C and F may be seen the little Membranes which encompass the *Fibrils*, but are here torn asunder. Fig. 61. exhibits four small *Fibrils* of a Piece of Flesh of another Whale, by which it plainly appears, that the Diameters of these *Fibres* are as small again as those in the foregoing Figure, therefore they must be four Times as big as these; as each fleshy *Fibre* is composed of a great many smaller *Fibrils*, we may imagine each of these inclosed ones, to consist also of others of the like Nature.

Mr. *Leeuwenhoek*, on viewing several small *Fibres* of Ox Flesh, observed each of its contained *Fibrils* to be encompassed with a thin Membrane; but could not shew these Membranes so distinctly to others in this Flesh, as in that of a Whale; because the Parts of the first are of a Texture much more compact and close, than those of the latter; for which Reason they do not shrink so much in drying. And is also of Opinion, that what he has said of the Membranes encompassing the *Fibres* and *Fibrils* of Whale-Flesh, will also hold true in other Kinds of Flesh, even down to that of a Rat or Mouse.

Mr. *Muys* confirms the foregoing Observations on the fleshy *Fibres* of the Muscles, being composed of smaller *Fibrils*, and computes that 500 or 600 of them may be reckoned into one fleshy *Fibre*, whose Diameter is the 24th Part of an Inch, * and that each of these *Fibrils* are also made up of more than 300 transparent Tubuli, but so slender as not to admit a 24th Part of a single Globule of Blood. He has shewn, that tho' the fleshy *Fibres* of the Muscles are joined to the Tendons, and tendinous Membrane of a Muscle; yet those tendinous *Fibres* are not a Continuation of the fleshy ones, as is generally supposed. He found that upon injecting warm Water into the crural Artery of a Lamb of a Year old, all the fleshy *Fibres* lost their Redness and became White. He then injected a colour'd Liquor into the same Artery, upon which not only the small Arteries appear'd replete with the tingid Liquor, but that it had also passed thro' each *Fibre*. He also observed, that several Branches of the Arteries now became visibly spread round the small *Fibrils*, and tingid with the same Liquor; and upon examining the Parts of the fleshy *Fibres*, near the Extremity of the Arteries with a Microscope, found the small *Fibrils* filled and tingid with the same Liquor; and not the least Appearance of the Liquor in the Interstices between the *Fibrils*. And upon injecting another colour'd Liquor by the crural Artery, he saw not only the *Fibres* in some of the Muscles, and most Part of them in others, filled with this Matter, but upon examining them in a good Microscope, found the *Fibrils*, and even the least

* *Phil. Transf.* No. 339.





Tubuli that compos'd them, filled and tingid with the same, yet the small Ramifications of the Nerves appear'd perfectly white. Whence it appears, that the small Tubes which form a *Fibril*, are really hollow; and that the Extremities of the capillary Arteries open into them, and empty therein a Part of their Liquor, which is re-conveyed by the Veins into the Heart.

In the spinal Marrow of an *Ox*, Mr. *Leeuwenhoek* tells us, he saw with great Delight minute hollow Vessels of an inconceivable Fineness, invested with their Membranes, and extending length-wise parallel to each other, make up their Composition. He did not only discern their Cavities, which he computed to be 3 times less than their Diameters, but in some perceived the Orifices, as the Holes in a prick'd Paper are seen, when held against the Sun. This Examination requires the utmost Dexterity. For after a thin Slice of the spinal Marrow is placed before the Microscope, in less than a Minute's Time it becomes dry, and the whole Appearance lost*.

He also examined the Brain of an *Indian Hen*, a *Sheep*, an *Ox*, a *Sparrow*, &c. and did in them distinguish Multitudes of Vessels extremely small; and farther † observ'd, that the Vessels in the Brain of a *Sparrow* are no smaller than in an *Ox*, and from thence he argues, that there is no other real Difference between the Brain of a larger and a smaller Animal, but only a greater or a smaller Number of Vessels; and that the Globules of the Fluid passing thro' them, are in both of the same Size.

C H A P. XIV.

Of Hairs.

FROM *Malpighi's* curious Observations of the *Hair*, we are informed, that they are compos'd of a Number of extremely minute Tubes, which are mostly distinguishable near the End of the *Hairs*, in a Horse's Main and Tail, and in the Bristles of a Boar, wherein those Tubes so manifestly appear, that he could sometimes reckon above 20 of them; and in the Hedge-Hog's Prickles, he plainly saw those Tubes, together with medullary Valves and Cells.

That which this sagacious and not enough to be commended Observer, took Notice of in the Structure of *Hair*, and its Parity to the *Spines*, § is observably true in some Measure in the *Hairs* of *Cats*, *Rats*, *Mice*, and in divers other Animals, which look very prettily when viewed with a good Microscope.

Fig. 63. A, B, C, represents three cylindrical Pieces of human *Hairs*, they are transparent throughout their whole || Length; and are composed of small

* *Arc. Nat. Tom. III. p. 310, 355, 440.* † *Ibid. Tom. I. Part I. p. 38.* § *Derham's Phys. Thef. p. 220.* || *Hook's Microgra. 1 Ed. p. 158.*

long tubular Fibres, encompassed with a Kind of Bark; from which Structure, the Ends of long Hairs when split, appear like a Stick shrivelled with Beating, some of them in *Men, Horses, Sheep, Hogs, &c.* having six or more Splinters.

Fig. 64. represents a cylindrical Piece of the *Hair*, or *Bristle* of an *Hog*, which is neither perfectly round nor sharp edged, but prismatical, with divers Sides and roundish Angles.

Part of a Whisker of a *Cat* cut transversely, is represented by the short Cylinder, Fig. 65. which seem'd to have a large Pith in the Middle, like that of Elder.

The *Hairs* of *Indian-Deer* appear perforated from Side to Side. The long *Hairs* of *Horses*, as at D E F, Fig. 66. seem cylindrical, and somewhat pithy.

The *Hair* of a *Mouse* seems to be one single transparent *Tube*, with a *Pith*, made up of a fibrous Substance, running in dark Lines, in some *Hairs* transversely, in others spirally, these darker medullary * Parts are no other than small Fibres convolved round; and lying closer together than other Parts of the *Hair*; they run from the Bottom to the Top of the *Hair*, and it is apprehended that they run round in a Screw-like Fashion. A B, Fig. 67. represents that Part of the *Hair* which grew near the Skin, the middle Part of the same *Hair* is shewn at C D, and the Point of it at E F.

Hairs taken from the Head, the Eye-brows, the Nostrils, the Beard, the Hand, and other Parts of the Body, appear unlike, as well in the Roots as in the *Hairs* themselves, and vary as Plants do of the same Genius, but of different Species.

Hairs have each a round bulbous Root, which lies pretty deep in the Skin, being planted in the pyramidal Papillæ, and, by this imbibe their proper Food from the adjacent Humours, and as hinted above, their Extremities split or divide in two or three Branches, especially when kept dry, and left to grow too long; so that what to the naked Eye appears only a single *Hair*, to the Microscope seems a Brush.

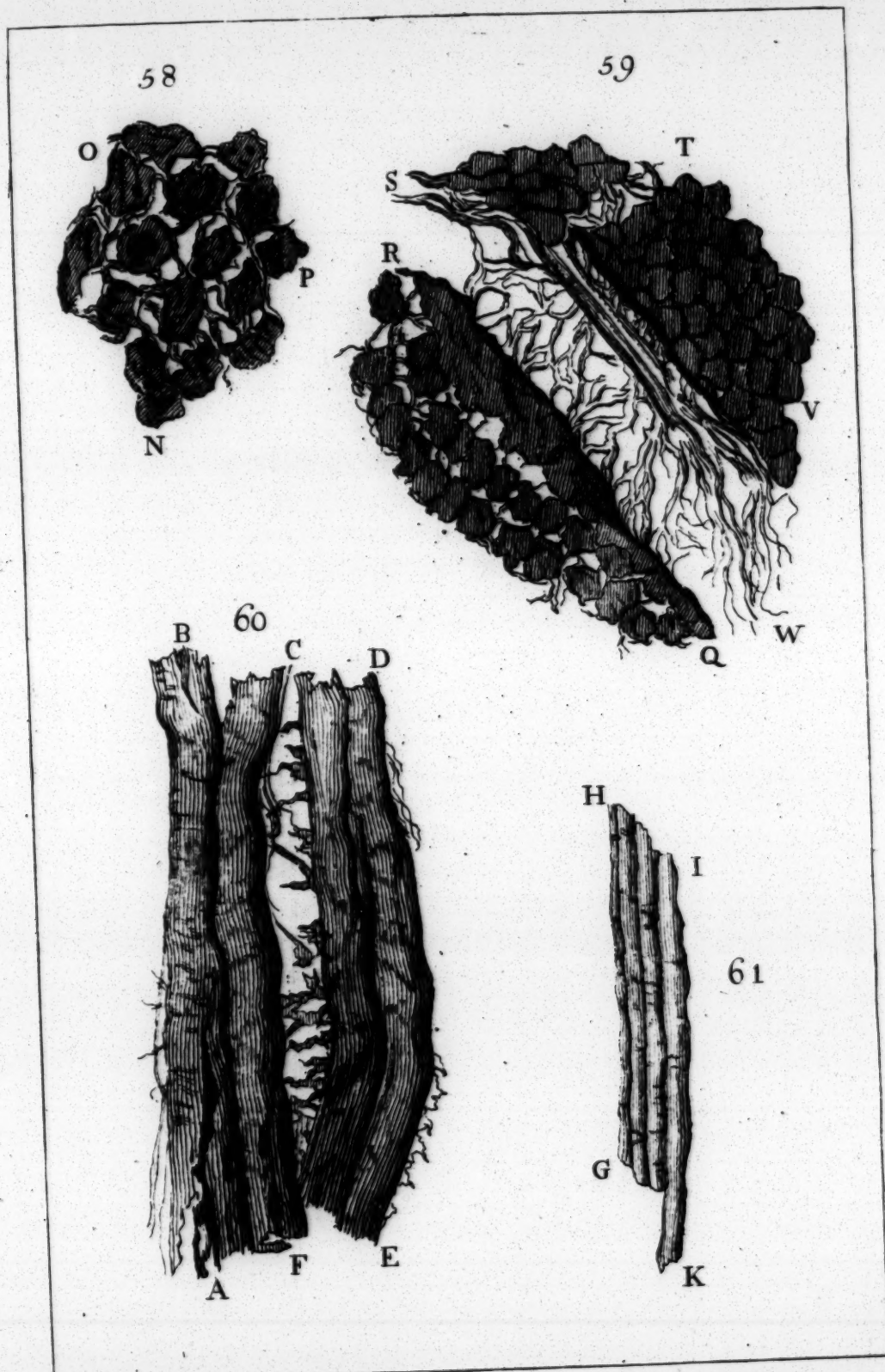
C H A P. XV.

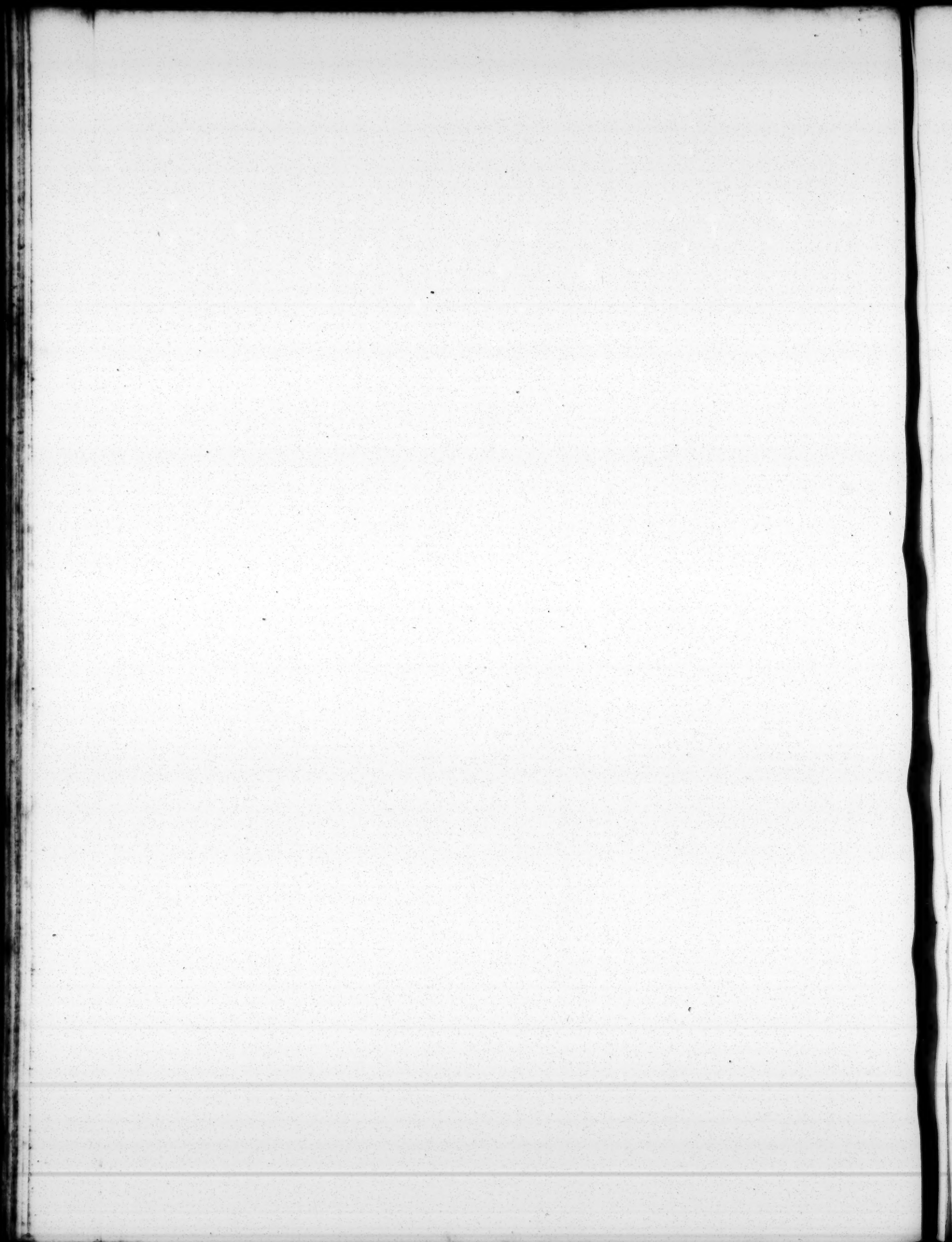
Of the Scales in Human Skin.

THE *Cuticula*, scarf *Skin*, or outward Covering of the Body, is remarkable for its *Scales* and *Pores*.

The *Scales* grow upon our Bodies, just as the *Scales* grow upon the ex-

* *Arc. Nat. Tom. III. p. 47.*





ternal Skin of a Fish, * and are placed as in Fishes three deep, *i. e.* each Scale is so far cover'd by two others, that only a third Part thereof appears, as at M, Fig. 70. their lying over one another, may be the Cause why the Skin of the Body appears white; for about the Mouth and Lips, where they only just meet together, and do not fold over, the Blood-Vessels are seen thro', and the Parts look red.

The perspirable Matter is supposed to issue between those *Scales*, (which lie over the Pores or excretory Vessels, through which the watery and oily Humours perspire) and may find Vent in an hundred Places round the Edges of the Skin.

A Piece of *Skin* taken from between the *Fingers*, *Neck*, *Arms*, *Forehead*, or any other Part of the Body which is not hairy, serves best to shew the *Scales*: Or if they be scraped off with a Penknife, and put into a Drop of Water, and so applied to the Microscope, they will be seen to good Advantage, as at L, Fig. 70. and generally consist of five Sides.

Mr. *Leeuwenhoek* tells us 200 of them may be covered with a Grain of Sand †, so that if a Grain of Sand can cover 200 of those Scales, it will also cover || 20,000 Places through which Perspiration may issue.

To view the Pores of the Skin.

Cut a Slice of the upper Skin with a sharp Razor, as thin as possible; and then immediately cut a second Slice from the same Place, which apply to the Microscope, in a Piece about the Bigness of a Grain of Sand, innumerable Pores will be perceived. If a Piece of the Skin between the Fingers, or in the Palm of the Hands, be thus prepared, and then examined, the Light may very pleasantly be seen thro' the Pores.

The Pores thro' which we perspire, are most remarkable in the Hands and Feet §; for if the Hand be well washed with Soap, and examined but with an indifferent Glass, in the Palm, or upon the Ends and first Joints of the Thumb and Fingers, innumerable little Ridges parallel to each other, of equal Distance and Bigness, will appear; upon which the Pores may be perceived by a very good Eye, but when view'd thro' a very good Glass, every Pore seems like a little Fountain, with Sweat standing therein, as clear as Rock Water, and if wiped away, it will be found immediately to spring up again.

* *Philos. Transf.* No. 159. † *Arc. Nat. Tom. I. Par. II. p. 208.* || *Arc. Nat. Tom. IV. p. 48.* § *Philos. Transf.* No. 159.

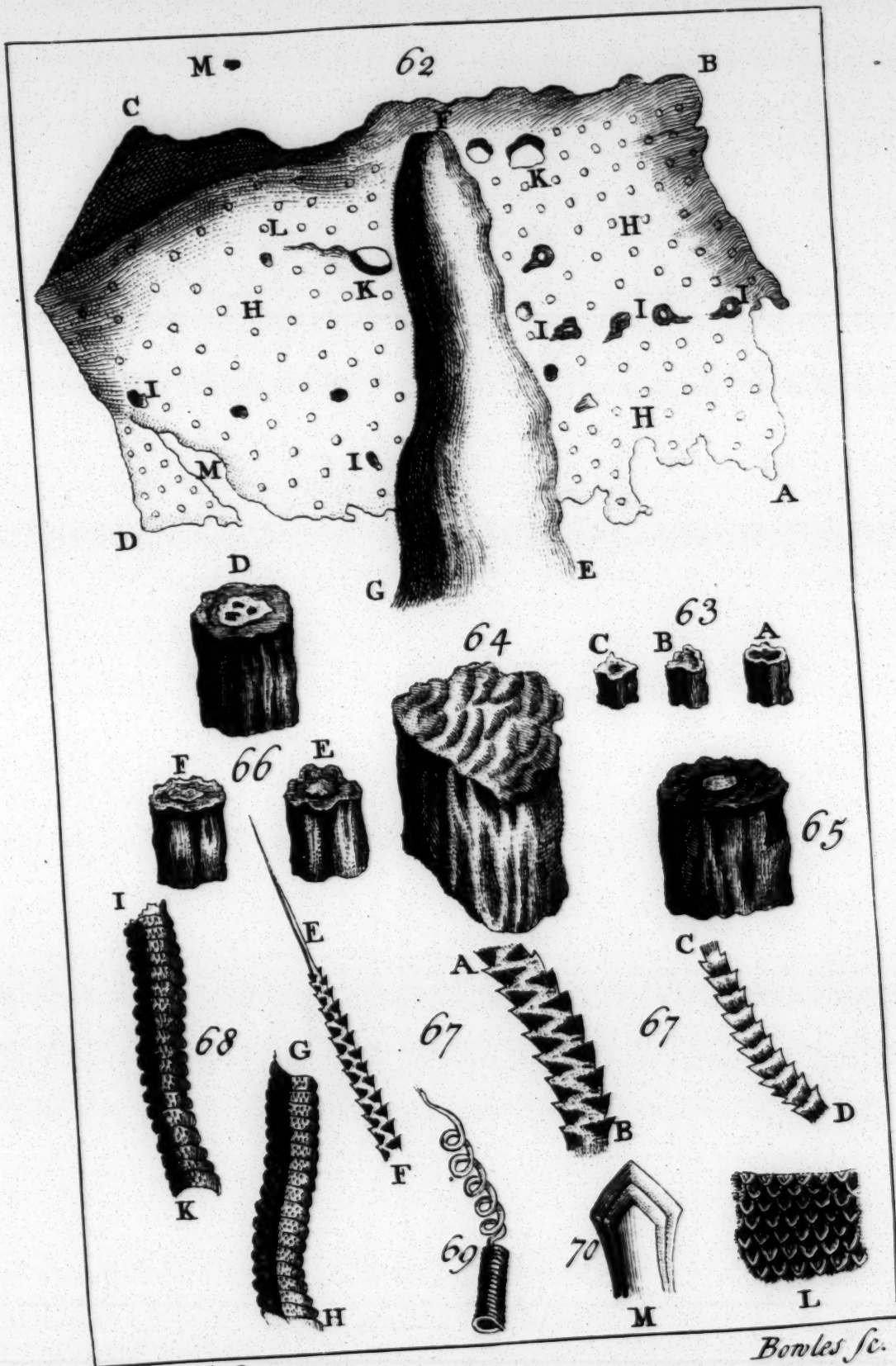
C H A P. XVI.

Of Feathers.

THE *Feathers* of most Sorts of Birds afford a beautiful Variety, observable in that incomparable Curiosity with which every *Feather* is made; the Vanes thereof are curiously gaged, broad on one Side, and narrow on the other; both which administer to the progressive Motion of the Bird, as well as to the Union and Closeness of the Wing; and no less exquisite is the textrine Art of the Plumage also, which is so curiously wrought, and so artificially interwoven, that it cannot be viewed without Admiration, especially if the Eye be armed with a Microscope.

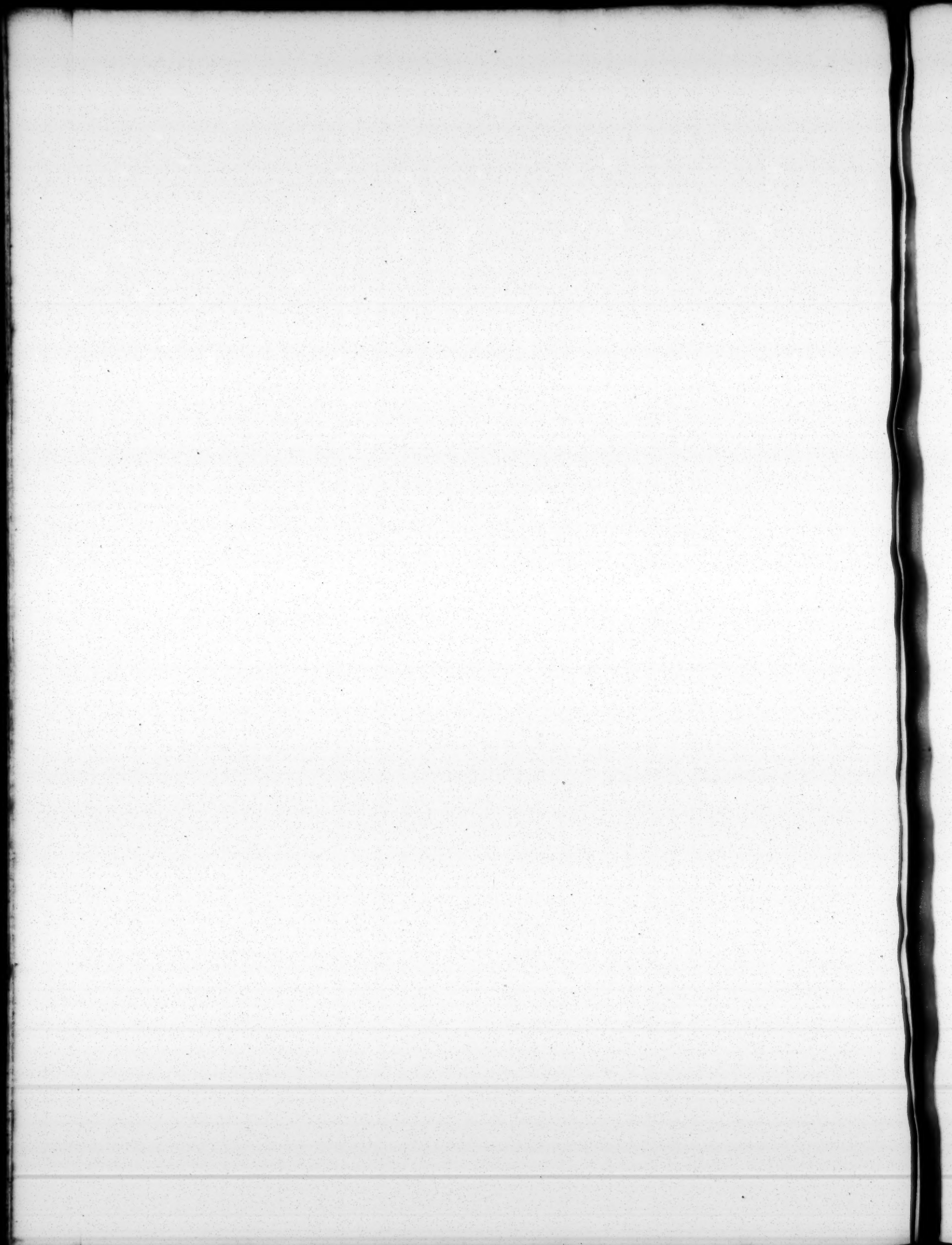
Mr. *Hook* observes, that the Make and Texture of their downy Parts are most admirable; for, says he, there is scarce a large *Feather*, but contains near a Million of distinct Parts, and every one of them regularly shaped; with his naked Eye he counted 300 of the long downy Branches on one Side, and an equal Number on the other Side of more stiff and shorter Branches, in a middle sized Goose Quill, and examining many of those long downy Branches with his Microscope, found several of them to contain near 1200 small Leaves, such as A B of Fig. 71. and as many Stalks on the other Side, such as A C, of the same Figure, each of these Branchings A B, seemed divided into 16 or 18 small Joints, out of most of which grew long slender Fibres, as are expressed in the Figure by a b c d, several of which terminated in a Hook; those on the other Side were much shorter, the Stalks A C were divided into as many knotted Joints, but without Strings or Hooks, being divided at D into two Parts, one Side extended from D towards C, in Length equal to A C, the other Side at D was very short. The transverse Section of these Stems or Branches, were shaped like E F G H, whose Covering appear'd like Horn, and the Pith like that of the main Stem of the Feather; these Stems or downy Branches are so ranged, that the Leaves or hairy Stalks of the one, lie at Top, or are incumbent on the Stalks of the other, and cross each other, much after the Manner of Fig. 72. by which Means, each of those little hooked Fibres get between the naked Stalks, which being full of Knots, and a pretty Way disjoined, the two Parts are so closely and admirably wove together, as to resist the Air; and are so extremely small, that the 500th Part of an Inch exceeds them in Thickness.

The Parts of the *Feathers* of a *Peacock*, appear through the Microscope no less beautiful than the whole *Feather* does to the naked Eye; the Stem of each *Feather* in the Tail, sends out Multitudes of lateral Branches; such as A B, of Fig. 73. which represents $\frac{1}{31}$ Part of an Inch, each of
these



Front. 1 Pag. 54.

Bowles sc.



these lateral Branches emits Numbers of little Sprigs or Hairs, on each Side as C D, C D, C D, each of which in the Microscope appear to consist of a Multitude of bright shining Parts, which are a Congeries of small Plates, as e, e, e, e, e, &c. each shaped like a, b, c, d, of Fig. 74. a c being a Prominency or Stem; and d and b the Corners of two small thin Plates, that grow into the small Stalk in the Middle, making a Kind of little Feather, and lie close to, or rather upon each other in the Manner of Tiling; they grow on each Side of the Stalk, opposite to each other, by two and two in the Manner expressed by Fig. 75. the Tops of the lower ones covering the Roots of those next above them; the under Sides of each of these Plates are very dark and opaque, reflecting all the Rays cast upon them; much like the Foil of a Looking-Glass; but their upper Sides seem to consist of a Multitude of exceedingly thin plated Bodies, lying close together, and thereby like Mother of Pearl Shells do not only reflect a very brisk Light, but even tinge that Light so reflected in a most curious Manner, which by various Positions of the Light, reflect first one Colour and then another, in a most vivid and surprizing Manner. And that these Colours arise only from the Refraction of Light: He found that wetting the colour'd Parts with Water, destroyed their Colours, and though he was not able to see those Hairs at all transparent in common Light, yet by looking at them against the Sun, found them to be tinged with a darkish Red, not at all resembling the curious Greens and Blues they exhibit.

The changeable colour'd *Feathers* of *Ducks*, and several other Birds; he found upon Examination with the Microscope to proceed from the same Causes and Textures.

The best Way to apply one of these small downy Fibres to the Microscope, is to pinch them between the Nippers.

Mr. *Derham*, in his Description of the Vanes of a Flag *Feather* of a *Goose's Wing*, observes these two Particulars, 1. That the exterior or narrow Vanes bend downwards; the interior, wider Vanes upwards; by which Means they catch hold, and lie close to one another, when the Wing is spread, so that not one *Feather* may miss its full Force and Impulse. 2. That the very Tips of these *Feathers* are also neatly sloped to a Point, towards the outward Part of the Wing. The exterior Vanes towards the Body.

The Vane or Web of a *Feather*, consists of several Laminæ, which are thin, stiff, and somewhat of the Nature of a thin Quill, towards the Shaft of the Feathers (especially in Flag *Feathers* of the Wing) those Laminæ are broad, and of a semicircular Form, which serves for Strength, and also for shutting these Plates close to one another, when Impulses are made upon the Air. Towards the outer Part of the Vane, these Laminæ grow slender and taper, on their under Side they are thin and smooth, but are parted

parted into two hairy Edges on the Upper: Each Side having a different Sort of Hairs laminated, or broad at Bottom, and slender and bearded above the other half.

The uppermost Edge of one of the Laminæ, with some of the Hairs on each Side, is represented in Fig. 76. as it appears a little magnified in the Microscope. These bearded Bristles, or Hairs, are streight on one Side thereof, as Fig. 77. those on the other Side have hooked Beards on one Side of the Bristle, and streight ones on the other, as Fig. 78. both these Bristles magnified (only scattering, and not close) are represented, as they grow upon the upper Edge of the Laminæ f t, in Fig. 76. and in the Vane, the hooked Beards of one Laminæ, always lie next the streight Beards of the next Laminæ, and by that Means lock and hold each other, and by a pretty Mechanism, brace the Laminæ close to one another. And if at any Time the Vane happens to be ruffled and discomposed, it can by this easy Mechanism, be reduced and repaired.

C H A P. XVII.

Of Flies.

S E C T. I.

THE common *Fly* is an Object beautifully ornamented with a Mixture of Silver and Black, and thick set with Bristles, pointing from its Head towards the Tail; in its Head are two large hemispherical Eyes, embroider'd with Silver Hairs, a wide Mouth, an hairy Trunk, and a Pair of short Horns. Its Trunk has two Parts folded over each other, and sheathed in the Mouth, whose Extremity is sharp. In those *Flies* which are of a light Colour and more transparent than others, the Motion of the Intestines may be plainly seen, and also the Motion of the Lungs, as they alternately dilate and contract themselves.

In general, the Female *Fly* is supplied with a moveable Tube at the End of her Tail, by the Extension of which she can convey her Eggs into convenient Receptacles, such as may afford a proper Nourishment to the Young. From these Eggs proceed minute Maggots or Worms, represented in Fig. 79. which after feeding voraciously for some Time, arrive to their full Growth, and are transform'd into little Aurelias as in Fig. 80. whence after a longer Space of Time, they issue forth perfect Flies, as Fig. 81.

S E C T. II.

Of the Feet of Flies, &c.

FIG. 82. A, is a microscopick Representation of the *Foot* of a *Fly*, in which is seen three of its *Joints*, the two *Talons*, and the two skinny *Palms* or *Soles* in a flat Posture. Fig. 82. B, shews only one *Joint*, the *Talons*, &c. in another Posture, which is so admirably and curiously contrived, as to enable the *Flies* to walk against the Sides of Glass, and to suspend themselves under the Surface of a Ceiling, with the greatest seeming Facility and Firmness. The two *Talons* A B, A C, are very large in Proportion to the *Foot*, the biggest Part of them from A to I I, is all hairy, their Points C and B smooth, and bending inwards. Each of these *Talons* are jointed at A, so that the *Fly* is able to open and shut them at Pleasure: The Claws readily enter the Pores of most Substances, at which Time, as the *Fly* endeavours to shut them, the Claws C B, do not only draw towards, but fix each other; and also draw the whole Foot G G A D D forward; so that on a soft Body, the Points G G G G (of which the *Fly* has about ten to each Foot) enter. This is sensible to the naked Eye, in the Feet of a Chaffer, and if you suffer him to creep over the Hand, he makes his Step as sensible to the Touch also.

But as this Contrivance often fails the Chaffer, so would it the *Fly*, had not Nature furnished his Feet with another curious Contrivance, which is the *Palms* or *Soles* D D. They are two small, thin, flat, and horny Substances, that arise from the under Part of the last Joint of the Foot, and are seemingly flexible; so that their two Sides do not always lie in the same Plain, but may be shut closer, and as it were grasp a Body of themselves: Besides, the under Sides of these Soles are all beset with small *Bristles*, like the Wire Teeth of a Card, whose Points tend forward. Hence the *Talons* drawing the Feet forward as before, and these *Soles* being applied to the Surface of the Body, with all its Points looking the contrary Way, if there be any Irregularity, or yielding therein; the *Fly* suspends itself very firmly and easily. That the *Fly* is enabled to walk on Glass, proceeds partly from a Ruggedness of the Surface, or a Kind of Tarnish or dirty smoaky Substance, adhering to the Surface of that very hard Body; and tho' the pointed Parts cannot penetrate, yet they may find Pores enough in the Tarnish, or at least make them. This Structure Mr. *Hook* surveyed with great Diligence, because he could not comprehend, that if there was any such glutinous Matter in those supposed Sponges (as most that have observed that Object in a Microscope, have believed) how the *Fly* could so readily unglew and loosen its Feet; and also because he had found no other Creature any Ways like it.

A Contrivance nearly alike to this is to be found in all Kind of Flies, and Case winged Insects, and in the Flea, in Mites, &c. some of which have only one sharp *Talon* at the End of each Leg. Which drawing towards the Center or Middle of their Bodies, enable these exceeding light Bodies to suspend and fasten themselves to almost any Surface. This will not seem strange; if we consider first how small their Bulk is when compared to their Superficies, their Thickness frequently not amounting to the 100th Part of an Inch. Secondly their Strength and Agility compared to their Bulk, which in that Proportion perhaps may be an 100 times stronger than an Horse: Thirdly, if we consider that Nature always appropriates the Instruments in the most fit, easy, and simple Manner possible to perform their Office; which is also verified in the Foot of a Louse, each of his Legs being footed with two small Claws, with which it grasps, and thereby moves itself to and fro upon the Hairs of the Creature it inhabits.

The Legs of Flies are best applied to the *Universal Microscope*, by being either stuck upon the Point, or held between the Nippers. Though we frequently place them between two Talcs in an Ivory Slider.

S E C T. III.

Of the Eyes and Head of a Grey Drone Fly.

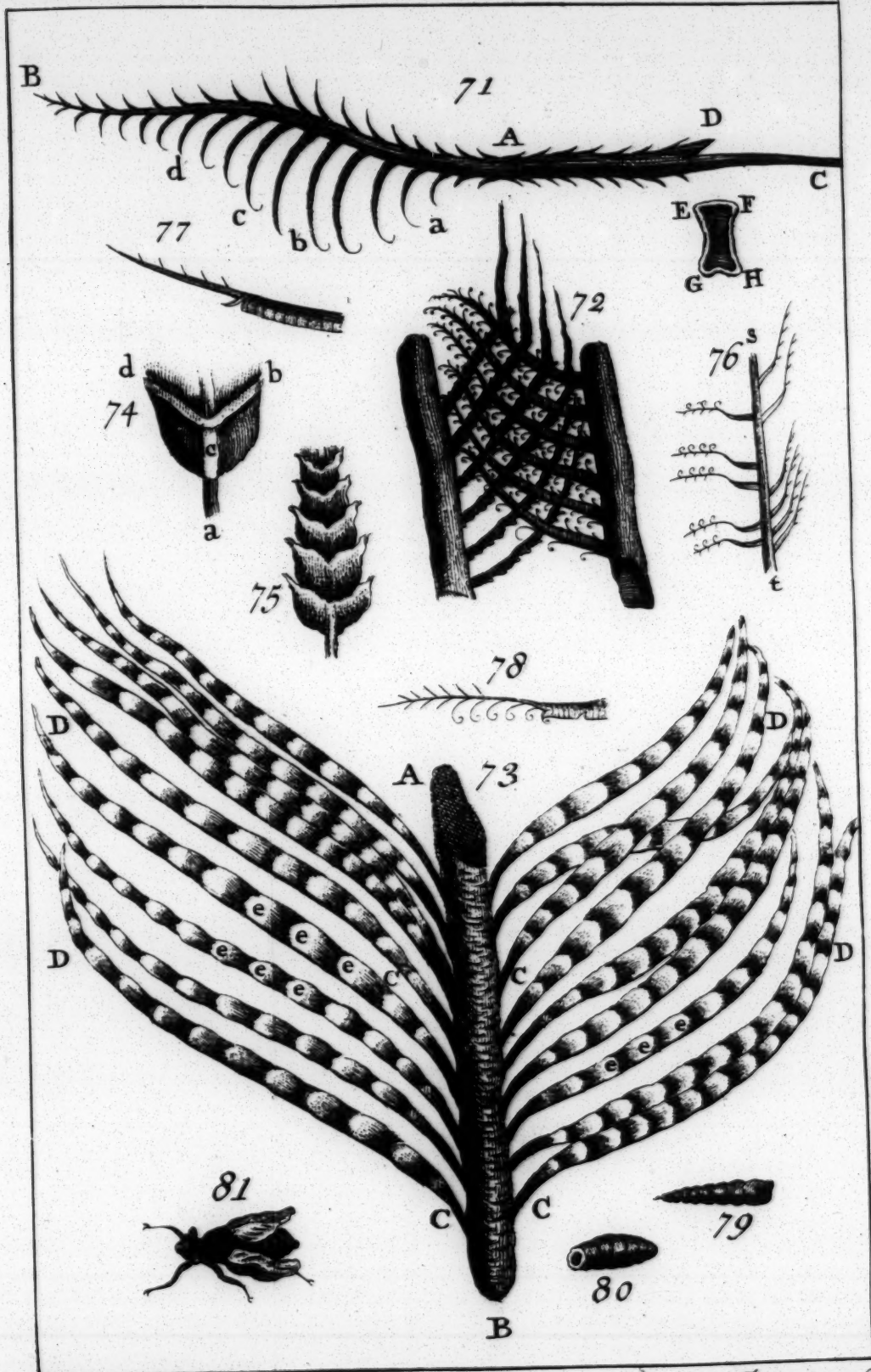
THE Structure of the *Eye* in all Creatures, is an admirable Piece of Mechanism; but the beautiful Contrivance of the *Eyes* of Insects is so peculiar, that it must excite our Admiration, so fenced with its own Hardness, that its own accurate Vision is a good Guard against external Injuries; its outward Coat being all over beset with curious lenticular Inlets, enabling those Creatures to see very accurately every Way, without any Interval of Time, or Trouble to move the Eye towards Objects *.

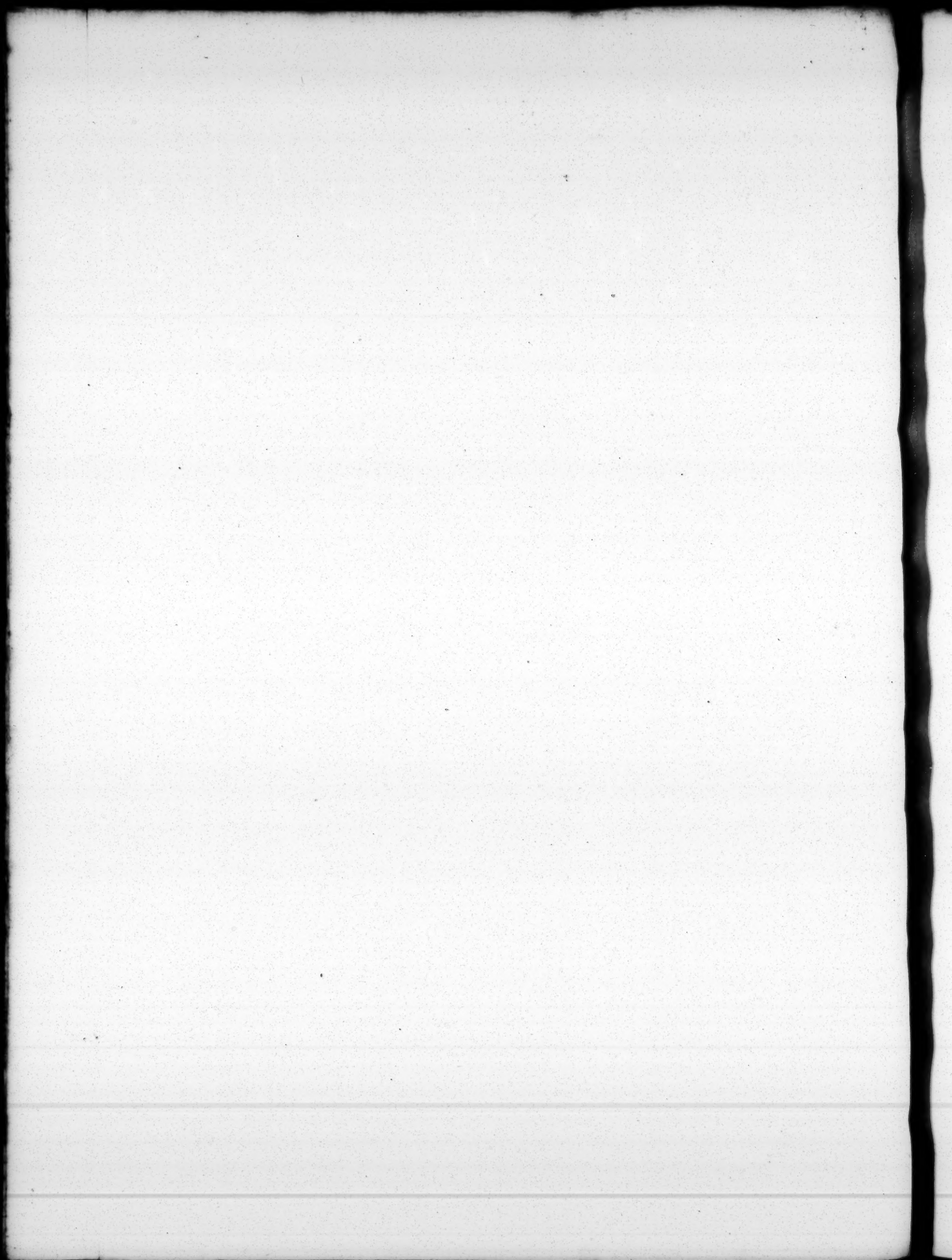
See Fig. 83. This *Fly* was made Choice of, because the Inquiry being chiefly about the *Eyes*, it was found to have the biggest Cluster of *Eyes*, in Proportion to its Head, of any other small *Fly*. It inclining something towards the Make of the large *Dragon Fly*, which is the most remarkable of all other Insects for its fine *pearled Eyes*.

The greatest Part of the Head was nothing else but two large Protuberances, A B C D E, whose Surface was cover'd over with a Multitude of small Hemispheres, placed with the utmost Regularity in Rows, crossing each other in a Kind of Lattice-Work.

That half of them C D E, C D E, which looked towards its Legs, were

* *Derham's Ph. Th. p. 171.*





observed to be smaller than the other half A B C E, A B C E, which looked upwards and sideways. The Surface of these Hemispheres were so exceeding smooth and regular, that in each of them Mr. *Hook* was able to discover a Landscape of those Things which lay before his Window, Part of which was a large Tree, whose Trunk and Top he plainly saw. Also the Motion of his Hand and Figures, if moved between the Object and the Light. These Rows of *Eyes* were so disposed, that no Object was visible from his Head, but some of these Hemispheres were directed against it: And further, that where the Trunk of the Body seem'd to hinder the Prospect, these Protuberances were elevated, so that a *Fly* may be truly said to have an Eye every Way. These little Hemispheres have each of them a minute transparent Lens in the Middle, each of which hath a distinct Branch of the *optick Nerve* ministering to it, and rendering it as so many distinct *Eyes*; so that as most Animals are binocular, *Flies*, *Beetles*, &c. are multocular, having as many Eyes as there are Perforations in their *Cornea* *. By which Means as other Creatures are obliged to turn their Eyes to Objects, these have some of their Eyes ready placed towards Objects nearly all round them.

Two of these optick Nerves are represented as delineated by Mr. *Leeuwenboek*, in Fig. 84. And in Fig. 85. are exhibited † a great many of them in a Cluster, as they appeared before the Microscope, whereof that Part of them which was situate next the Cornea is shewn by the Letters N O P; it is also observable, that those Nerves, which were nearest to the Circumference of the *Cornea*, were shorter than those next within them; and so on, till they arrive at the *central Nerve*, which is the longest of all.

The Number of the Pearls in this *Fly*, Mr. *Hook* reckon'd to be 14000. Mr. *Leeuwenboek* computed 6236 in a *Silk-worm's* two Eyes, when in its *Fly State*; 3181 in each Eye of a *Beetle*; and 8000 in the two Eyes of a common *Fly*.

Cut off the Eye of any *Fly*, and with a Pencil, and some clean Water wash out all the Vessels; those Vessels may be examined by the Microscope, and then if you carefully dry the outward Covering, so as not to let it shrink, it will be rightly prepared for making Experiments; and upon viewing it, we shall distinguish the numerous Protuberances or Hemispheres divided from one another with a small Light, issuing between them, and six Sides to each. Mr. *Leeuwenboek* having prepared an Eye in this Manner, placed it a little farther from his *Microscope* than when he would examine an Object, so as to leave a right and exact focal Distance between it and the Lens of his Microscope; and then look'd thro' both, in the Manner of a Telescope, at the Steeple of a Church, which was 299 Feet high, and 750 Feet from the Place where he stood; and could plainly see through

* *Derb. Phy. Theo.* p. 372. † *Arc. Nat. Ep.* 111.

every little Lens, the whole Steeple inverted, tho' not larger than the Point of a fine Needle; and then directing it to a neighbouring House, saw thro' Abundance of the little Hemispheres, not only the Front of the House, but also the Doors and Windows, and was able to discern distinctly whether the Windows were open or shut.

An Eye of a *Fly* thus prepared, may be held between the Nippers for Examination. But the Head of any *Fly* is best seen when stuck upon one of those Ivory Slips, or Pieces of Card, or Holly, with some strong Gum Water, and applied to the Microscope under the Silver Reflector, which Slips may be held in the Nippers.

N. B. The Horns F F, the Feelers G G, the Proboscis H H, and the Hair and Bristles K K, shall be described in Sect. V. of this Chapter.

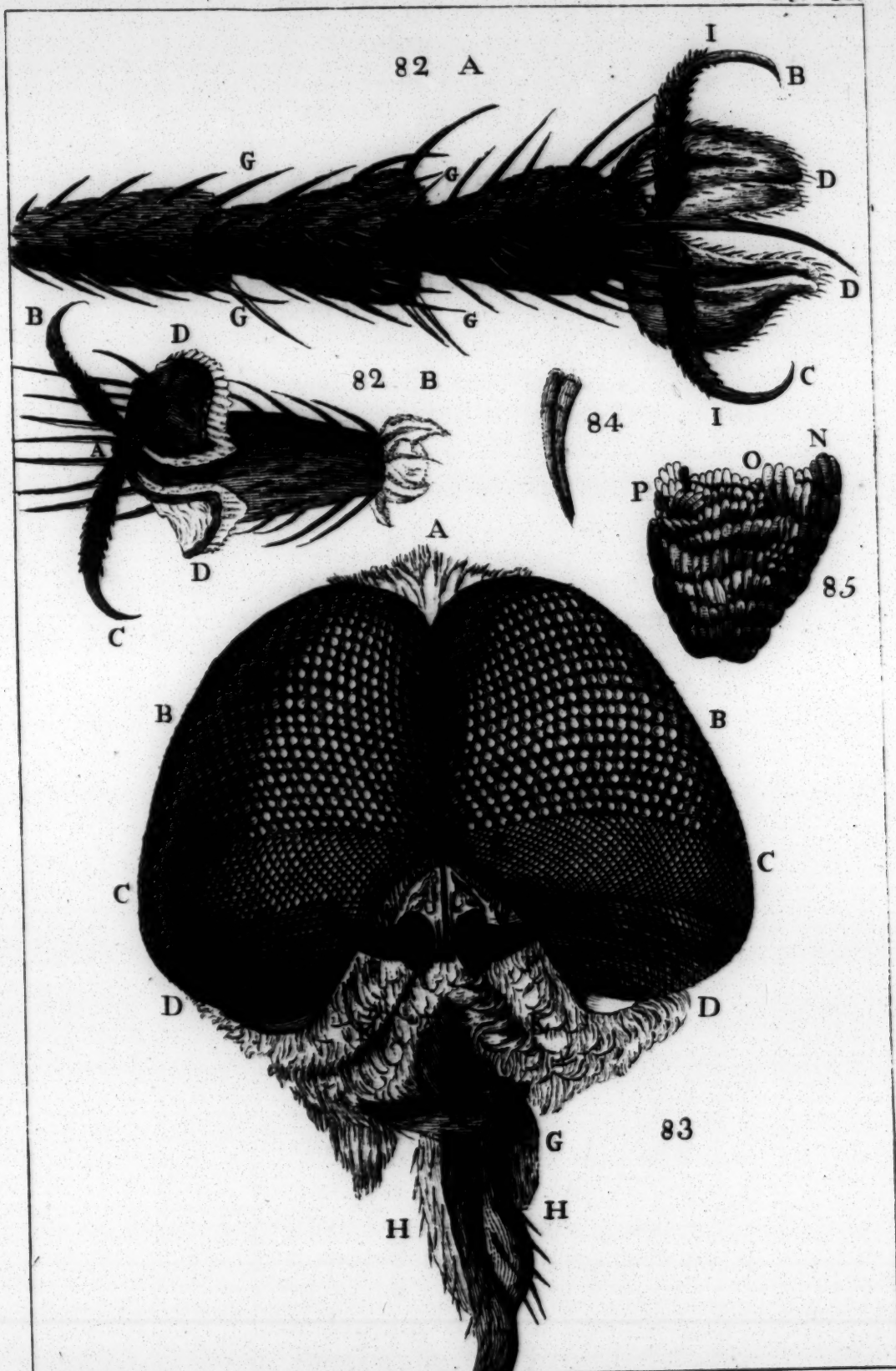
S E C T. IV.

Of the Wings of Flies.

THE *Wings* of all Kinds of Insects afford an infinite Variety, no less agreeable to the Mind, than pleasing to the Eye; being distended and strengthened by the *finest Bones*, and cover'd with the *lightest Membranes*. Some of them are adorned with neat and beautiful Feathers, and many of them provided with the finest Articulations and Foldings, for the Wings to be withdrawn, and neatly laid up in their *Vagina* and Cases, and again readily extended for Flight.

This of the *blue Fly*, Fig. 86. here exhibited, is not without its peculiar Ornaments; it grows out of the middle Part of the Body of the *Fly*, and is seated a little beyond the Center of Gravity thereof, towards the Head; but that is curiously ballanced by the expanded Area of the Wing, which consists of several *bony Ribs*, that give Strength to the filmy Parts; which are thickly beset with innumerable small Bristles, intermixed with as many dark Spots, which seem to be the Roots of the Hairs that grow on the other Side.

Of other *Flies*, some of their *Wings* are *filmy*, as the *Dragon Flies*; others stuck over with short *Bristles*, as the *Flesh Fly*; others have divided *Wings*, as the *grey* and *white feather'd Moths*; many Sorts of *Gnats Wings* are adorned with Rows of Feathers along their Ridges, and Borders of Feathers round their Edge; some have Hairs, and others Hooks, placed with the greatest Regularity and Order. In the *Butterfly* and some *Moths*, there are an infinite Number of small Feathers, which cover both the under and upper Surfaces of this thin Film, not only shaped much like the Feathers of Birds, but also variegated with the greatest Variety of curious
bright





bright and vivid Colours; which is evident to the naked Eye, but much more entertaining when viewed thro' the Microscope; by which we are informed, that these curious colour'd minute Feathers end in Quills, and are placed in orderly Rows with great Exactness, as the Holes they come from shew when they are rubb'd off.

Fig. 87. represents a small Piece of a *Butterfly's Wing*; A B shews one of those *bony Ribs* that gives it Strength, along whose Sides are supposed to branch out various *Blood-Vessels*, conveying Nourishment to the intermediate Parts; although no Circulation can be discern'd therein, we can scarce doubt but that a continual Supply of Juices must be carried on to these minute Quills, Hairs, and Bristles; C, C, C, exhibits three of these single Plumes, with their Quills adhering to the transparent Membrane of the Wing, in which Membrane G, G, G, when divested of its Feathers, may be seen, the Order of Pits or Holes where the Quills are rooted, and from whence they shoot, D, E, F, shews a few of the Feathers exactly in the Form as they cover the whole Wing.

Some *Flies* have Hairs, and all the Scarab Kind have Elytra, or Cases into which their Wings are folded and preserved, till they want to employ them, as in Fig. 110. some of these Cases reach almost to the Extremity of their Tail, as in most Kinds of *Beetles*; and in others are very short, as in the *Earwig*. They do by a very curious Mechanism extend and withdraw their membranous Wings. It is very curious to see them prepare themselves for Flight, by thrusting out, and then unfolding their Wings; and again withdraw those Joints, and neatly fold in the Membranes, to be laid up safe in their Elytra or Cases; for which Service the Bones are admirably placed, and the Joints ministering thereto are accurately contrived for the most compendious, and commodious folding up of the Wings.

Mr. *Hook* hath observed the Motion of these filmy Wings in some minute spinning Flies, which naturally suspend themselves as if pois'd and steady in one Place of the Air, in which by a faint Shadow he could perceive the utmost Extremes of the vibrative Motion; which Shadow, while they endeavour'd to suspend themselves, was not very long; but when they endeavour'd to fly forward, it was something longer; he also fixed the Legs of a Fly with Glew or Wax, upon the Top of the Stalk of a Feather, and then making it endeavour to fly away, was thereby able to view it in any Posture; and found the Motion of the extreme Limits of the Vibrations, to be about the Length of the Body distant from each other; and concluded by the Sound, that the Wing was moved forwards and backwards with an equal Velocity, (and comparing it with a musical String tuned Unison to it) the Vibrations whereof are so swift, that it is probable there are many hundred, if not thousand Vibrations in one Second of Time, and supposes them the swiftest Vibrations in the World; whence he reflects on the Quickness of the animal Spirits, which serve to supply this Motion.

It is observable that most Insects are provided with a little Ball, * or Bladder under each Wing, fix'd at the Top of a slender Stalk, moveable every Way at Pleasure; in some they stand alone, in others (as in the whole *Flesh Fly* Tribe) they have little Covers, under which they lie and move; with these Poises, and secondary lesser Wings, they obviate all the Vacillations of their Body, and poise it in Flight, as a Rope-Dancer ballances himself by his Pole loaden at each End with Lead.

If one of these be cut off, the Creature flies awkwardly for a-while, and at last falls to the Ground. These Bladders being hollow, may serve likewise to produce the Noise many Sorts of Flies make by striking their Wings against them; Insects that have four Wings ballance themselves with the two lesser ones.

The Wings of Flies are best applied to the Microscope between two *Muscovy* Talcs, in an Ivory Slider.

If with an Hair Pencil, or Point of a Penknife, you gently brush or stroke off some of the minute Feathers from the Wings of *Butterflies*, and some Sort of Moths; then breathe upon a single Talc in one of your Sliders, and apply it to the Feathers, which seem only like a fine Dust, they will immediately adhere to it; if upon their Application to the Microscope they lie not to your Mind, wipe them off, and put on others in the same Manner, till they lie fair for Examination, then cover them with another Talc, and fasten them down with a Ring.

S E C T. V.

Of a Blue Fly.

FIG. 86. represents a microscopical Picture of this *Fly*; it has many Things about it worthy of Note; several of which are already described, *viz.* the Head, Eyes, Wings, and Feet.

The Clusters of Eyes in this *Fly* are much smaller than that of the *Drone Fly* in Proportion to its Head. Between these two Clusters of Eyes appear'd a scaly Prominency B, armed and adorned with black Bristles, sharp, and tapering, growing in Rows on either Side, and bending towards each other, formed a Kind of bristly Arbor, which almost cover'd the fore Front; at the End of this Arch, and about the middle of the Face on a rising Part C, grew two oblong Bodies D D, which through the Microscope looked not unlike the Pendants of Lillies, and appear'd to be jointed on two small Parts at C, each of which seem'd again jointed into the Front: Out of the upper Part of each of these Horns grows a Feather, or brushy Bristle E E,

* *Der. Phy. Th. p. 377.*

on the under Part of the Face F F, were several of the former Sort of bended Bristles; and below all is the Mouth, out of which grew the Proboscis G H I; which by Means of several Joints, the *Fly* was able to move to and fro, and to thrust in and out as it pleased. The End of this hollow Body, which was cover'd over with short Hairs, seem'd bent at H, and the foremost Side of the bended Part slit into two Chaps * H I, H I. These he could open and shut very readily, and when he seem'd to suck any Thing from the Surface of a Body, he would spread those Chaps, and apply the hollow Part of them close to it.

From either Side of the Proboscis, within the Mouth, grow two small Horns K K, which were hairy and small in this Figure, but of another Shape, and bigger in Proportion in Fig. 83. where they are marked G G, which two are generally called, the Antennæ or Horns of Insects; Mr. *Derham* imagines them to be absolutely necessary to the searching out and finding their Way, † as their Eyes are immoveable; so that no Time is requir'd for their turning them to Objects; there is no Necessity that the Retina, or optick Nerve, should occasionally be brought nearer to, or removed farther from the Cornea, as it is in other Animals; but their Cornea and optick Nerve being always at the same Distance, and fitted only to see distant Objects, they would be insensible of, and apt to run their Heads against Bodies very near them, were they not assisted by their Feelers: And that this, rather than wiping the Eyes, as some have imagined, is the particular Use of the Feelers, and is apparent from the *Flesh Fly*, and many other Insects, which have their Antennæ so short and streight, as not to be capable of being bent unto, or extended over the Eyes.

The middle Part of this *Fly* was cas'd with a firm Coat of Armour, the upper Part of which was thickly beset with conical Bristles, pointing backwards; from its under Part sprang six Legs, three of which are apparent in the Figure at M, N, O; they were all of the same Structure, being cover'd with an hairy Shell, and composed of eight Joints, to the last of which grew the Soles and Claws before described in Page 57. From the upper Part of the Trunk grew the two Wings, which are described Page 60; the hinder Part of his Body was of a most curious shining Blue, and exactly like polished Steel, brought to that Colour by Nealing.

The lamellated *Antennæ* of some, the cavelated of others, the neatly articulated of others, and the feather'd or tufted of others, are exceedingly beautiful when viewed through a Microscope.

And in some these *Antennæ* distinguish the Sexes, ‖ for in the Gnat Kind all those with Tufts, Feathers, or Brush Horns, are *Males*; and those with short single shafted *Antennæ*, are *Females*.

* *Hook's Mycro.* p. 183. † *Derham's Phy. Theo.* p. 372. ‖ *Derham's Phy. Theo.* p. 373.

Flies of any Kind may be examined in the Microscope, by sticking them upon the Point, or pinching any Part of them between the Nippers, and so applied to the Magnifier under the reflecting Concave, if it be opake. And if you are desirous to keep its Head, or any other Part, it may be stuck with Gum Water upon a Piece of Card, or upon one of those Ivory or Holly Slips, mentioned before in Page 31.

It is very observable, that *Insects* take particular Care to deposite their Eggs or Seed in such Places, where they may have a sufficient *Incubation*, and where the Young, when hatched, may have the Benefit of proper Food till they become able to shift for themselves. Those whose Food is in the *Water*, lay their Eggs in the Water; those to whom *Flesh* is a proper Food, in *Flesh*; and those to whom the *Fruits* or *Leaves* of Vegetables are Food, are accordingly repositied, some in this Fruit, some in that Tree, and some in that Plant, and some in another, but constantly the same Kind in the same Tree, &c.

As for others that require a more constant and greater Degree of Warmth, they are provided by the parent Animal with some Place in or about the Body of other Animals; some in the Feathers of Birds, some in the Hair of Beasts, some in the Scales of Fishes, some in the Nose, some in the *Flesh*, nay some in the Bowels and inmost Recesses of Man, and other Creatures. And as for others, to whom none of these Methods are proper, they make them Nests by Perforation in the Earth, in Wood, in Combs, and the like, carrying in, and sealing up Provisions that serve both for the Production of their Young, and for their Food when produced.

In *Flies*, *Butterflies*, &c. it is observed there is a kind of Gluten, by which the Female fastens her Eggs to the bearing Buds of Trees, &c. so that the Rains cannot wash them off, nor the severest Frost hurt them.

S E C T. VI.

Of Insects that infest Fruit and other Trees.

THESE *Insects* are of the Ichnumon Fly Tribe, that generated in the Plumb, is black, of a Middle Size, its Body near $\frac{3}{10}$ ths of an Inch long, its Tail not much less, consisting of three Bristles, wherewith it conveys its Eggs into Fruit, its Antennæ long, slender, recurved; its Belly longish, tapering, small towards the Thorax, Legs reddish, Wings membranous, thin and transparent, in Number four.

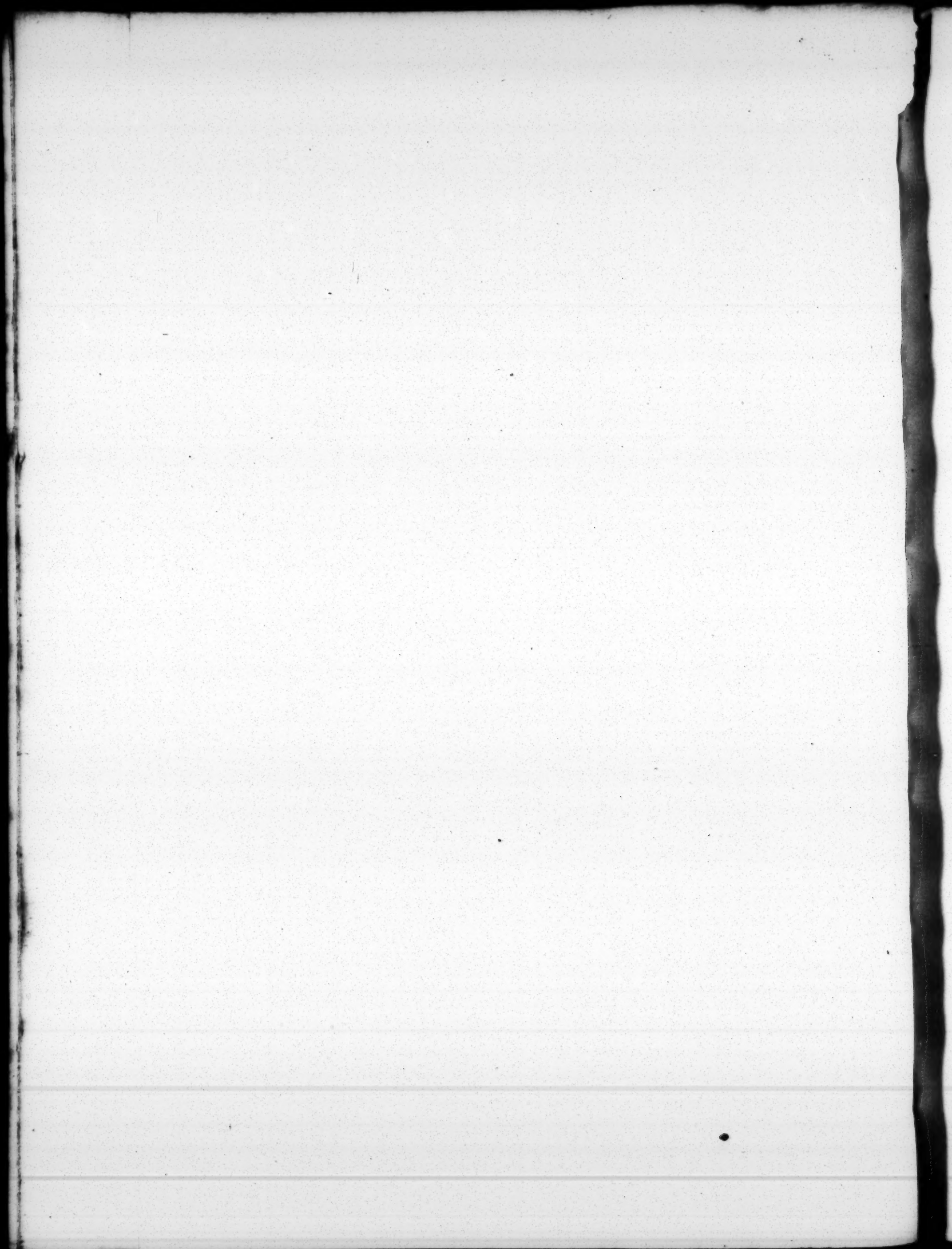
The Blossoms of Apples and Quinces are infested with Multitudes of small Animals, so likewise are the green Leaves of Goose-berry, Currant, Cherry, Grape, Plumb, and other Trees, overstock'd with infinite Numbers of these minute Flies. Some blackish, others green, some winged, others without

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Front? Pag. 64.

Bowles sc.



Wings; several of which bring forth their Young alive and perfect; for if their Bodies be opened, several imperfect Embrio's may be found therein. Also Insects of a greenish Colour of the Shape of Fig. 88. but no bigger than a Grain of Sand when first hatched, which at full Growth appear to the naked Eye of the Size of Fig. 89.

These little Insects *Leeuwenboek* calls *Pediculus*, * or *Louse*, who on plucking a Leaf from a *Plumb-tree*, and putting it into such a Glass Tube as is describ'd Page 30, which he applied to his *Microscope*, and found thereon 36 black Flies, and several hundred of these *green Lice*, and among them many which were but just hatched. In a short Time these green Lice died, and from their Carcase came forth a black Fly. Fig. 88. represents the Carcase of one of the *green Lice* as it appear'd before the *Microscope*. The Shell or Skin of its Back had several Rows of Knobs upon it; its Eyes A B were like those of other Flies; C D shew its two Antennæ articulated and set with Hairs. E F G H I K shew the Legs, having at their Extremity two hooked Nails, and short Hairs. L M represents the Aperture, from whence came out the Worm, from which the Fly was produc'd, having first eaten up all the Inside of the Body of the *green Louse*.

Fig. 90. exhibits one of these minute *black Flies* thus produced from a Worm, which had increas'd itself by destroying its foster Parent, and then changed into a Nymph, and at last from that to a Fly, furnished with all those minute Organs as are expressed in the Figure; whereof A B shews its two Eyes, C D its Antennæ, which afford a pleasant Sight in the *Microscope*, its curious Joints being finely beset with Hairs.

E F are two Organs, through which it sucks its Nourishment, its long Tail G H I, K L M N, its four Wings bedeck'd with exceeding fine Hairs and a much finer Membrane, O O O O O O its six Feet, which were also furnished with many Joints, and thickly set with Hairs. The Letters P Q R express the Point of the Nippers which held the Fly before the *MICROSCOPE*. These Lice are also to be found upon the Leaves of *Filberd-Trees*, with this Difference, the former being *green*, and the latter *white*.

Upon the *Leaves* of *Apples* and other *Trees* are found a curious *Fly*, † the exquisite Make and Form of its Parts are not to be discerned without a *Microscope*, Fig. 91. represents the Size and Shape it appears of to the naked Eye. And Fig. 92. a Part of its Head, whereof A B are its two protuberant Eyes, C D E its Snout, furnished with various Forceps or Teeth, with which it perforates the Buds of Fruit and Flowers; this Snout is flexible and capable of bending every Way, C F and D G are the two Horns which adorn the Snout. Fig. 93. is almost a fourth Part of the Leg of this Fly, which consists of four Joints. H I are two Nails which appear

* *Arc. Nat. Ep.* 135. † *Leeu. Ex. & Con. Epist.* 89.

in the Microscope, as Horn does to the naked Eye, and K L shews its two skinny *Palms* or *Soles*.

There is another Sort of Animalcule found in the Wrinkles and wreathed Curls of *blighted Leaves* *, and in the *Extremity* of the *Sprouts* of *Leaves*, as in *Garden Currants*, *Cherries*, *Peaches*, *Nectarines*, &c. may be found great Swarms of these minute Insects, no bigger than an half-grown Louse, one of which is represented by Fig. 94. of its full Growth, and of the Size it appear'd of to the naked Eye. Fig. 95. shews the same magnified and near its last Change, the folded Wing just beginning to appear at A B. It had six small jointed Feet, fenced with short Hairs, and two Nails on each; C shews one of its Eyes, which was of a surprizing Make. D F represents the Proboscis, with which it perforates the Leaves and Buds of Trees, and then thrusts out its Dart E and sucks their Juice. From its Tail proceeds two upright Parts G H, out of which a transparent Liquor is frequently diffused as at H. I K L is the Needle's Point, upon which the Animal was stuck; and Fig. 94, as before hinted, the same Animal when changed into a Fly.

Mr. *Derham* could never observe any other kind of Fly but the lesser *Phalænæ* † about $\frac{1}{10}$ of an Inch long to be bred in *Pears* and *Apples*; it is whitish underneath, greyish brown above, spotted about one Third with Waves of a Gold Colour, its Head small, a Tuft of whitish Brown on its Forehead, and Antennæ smooth. The Aurelia of this Moth is small, of a yellowish Brown.

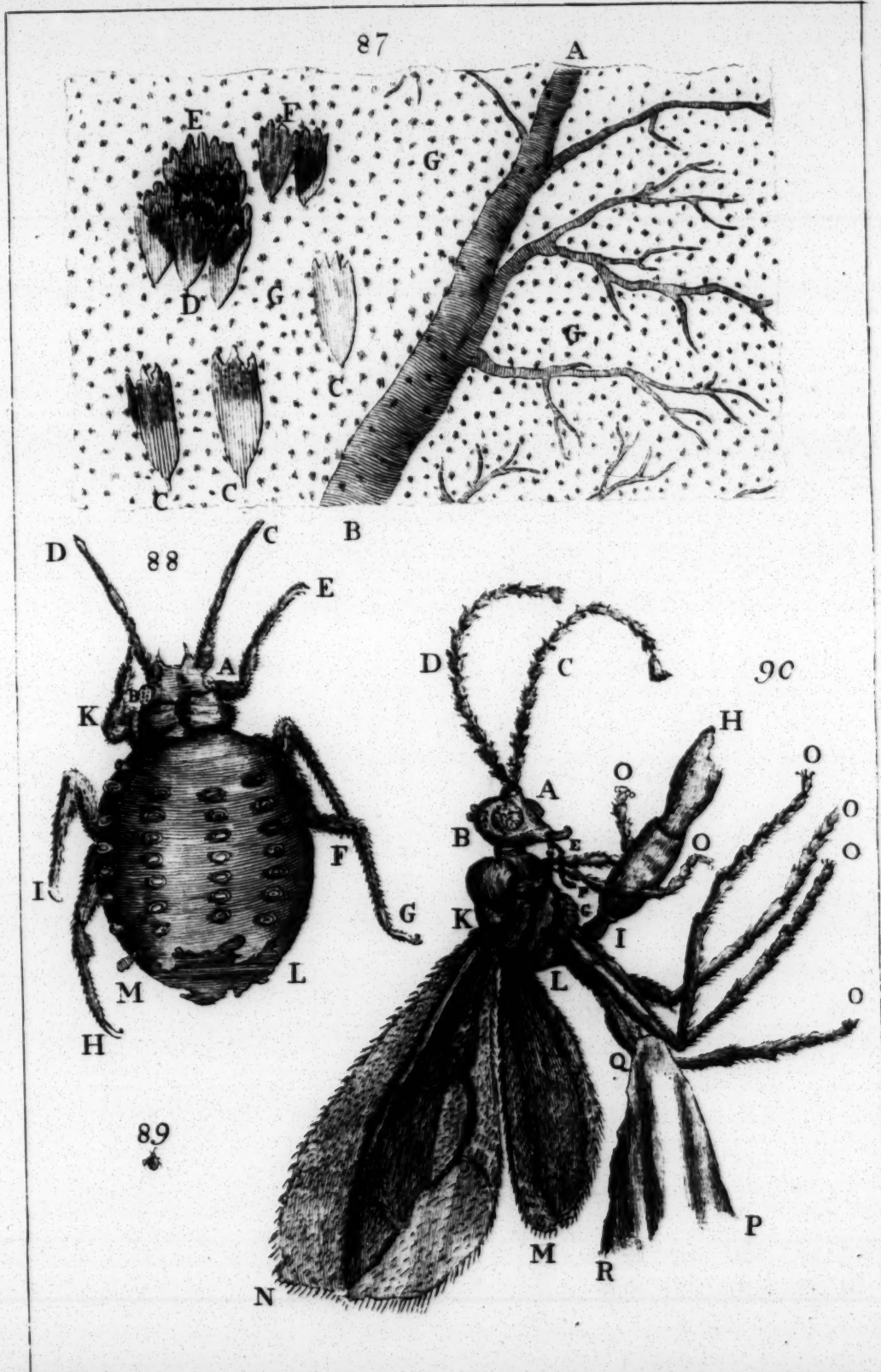
S E C T. VII.

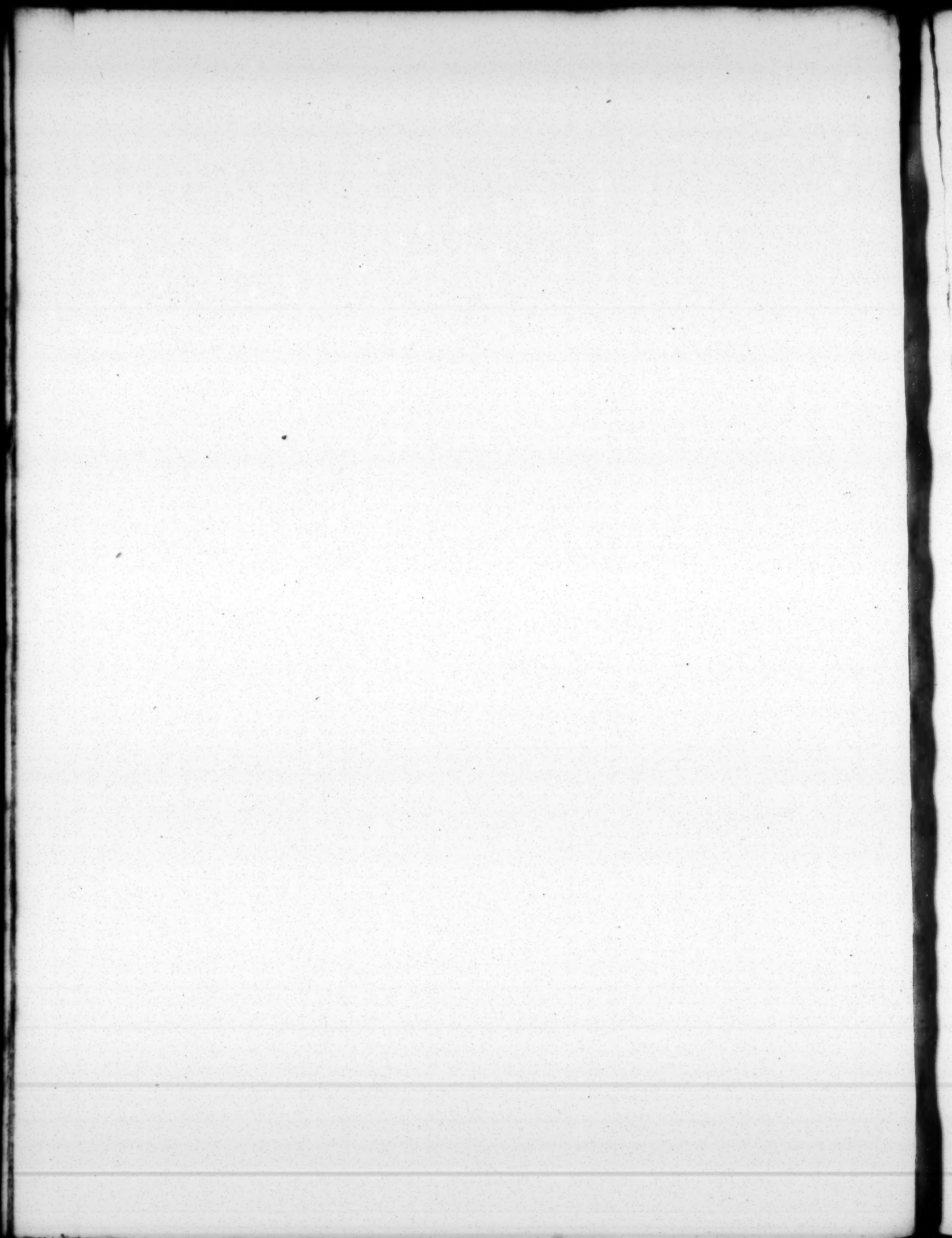
Of Excrescencies growing on Willow-Leaves, and a small Fly bred thereon.

MR. *Leeuwenhoeck* frequently discovered more than one Sort of Worm upon opening the knotty Part of *Willow-Leaves*, and having put several of these Knots, whose contain'd Worms were not full grown, into a large Glass Tube, that the Worms might attain their full Growth, could not find that any of them did so; observing at the same Time several of these Knots to have none of the Worms in them, but almost full of the Excrements of the Worms which had been therein, and were dislodged, through a small Hole he could perceive in the Knots.

Fig. 96. A B represents a *Willow Leaf*, in which are several *Excrescencies*, some of them with Holes as F, others as C D E; G H shews two of these Knobs cut open, and the Posture of the Worm therein, several Worms lay dead

* *Leeu. Ex. & Con. Epist.* 90. † *Ph. Theo.* p. 387.





in the Knobs supposed to be killed by other lesser Worms, produced from an Egg deposited by another Fly since the Production of the former, which devoured and lived upon the larger Worm.

In the Middle of July Mr. *Leeuwenhoek* cropt several *Willow-Leaves*, in which were such like Knobs *, and discovered several Worms nearly arrived to their full Growth: After these Knobs had been in the Glass Tubes about eight Days, upon opening one of them he found, that the Worm was turned into a *Tonnekin* or *Aurelia*, and in some others 13 or 14 more of the same; in some of the Knobs he found the small *devouring Worms* above-mentioned, being so far advanced in Growth that they were ready to be chang'd into flying Insects; he put these also into Glass Tubes. After some Weeks certain *black Flies* proceeded from those *Tonnekins*, their hinder Parts of an oblong Figure, and fashioned like a Hook. He also saw two of these small Worms (which devoured the large ones) endeavouring to enclose themselves in a Web; but by reason of the large Space in which they lay, could not bring it quite round them, having made it only on one Side, and their Change happened in so short a Time that he could not make his Remarks thereon.

Fig. 97. represents the aforesaid Fly as it appears to the naked Eye. A B shews the long, slender and hooked Part; on examining this little Instrument in the *Microscope*, it appear'd to be hollow, and was cover'd with a great Number of fine Hairs, as in Fig. 98. and on endeavouring to split it, the Dart, Fig. 99. appear'd, whose Point is only jagged with saw like Teeth, which being also split, two other distinct Hooks † were taken out of it both of the same Shape, a small Part of one of them is represented by Fig. 100. each of them being fortified with saw-like Teeth, and the Dart Fig. 101, was found to be only a second Case or Sheath for the two Hooks, wherein the Hollowness does plainly appear, which is filled with a corrosive Water. The Fly makes use of this Auger to prepare a convenient Lodgment for her Eggs (and chooses those Leaves that are most lacteous and juicy) under the Skin of the Leaf, from whence the Worm upon gnawing the Vessels for its Sustenance, occasions the Sap to flow out of them and to coagulate into that knotty Substance. Mr. *Leeuwenhoek* took a small devouring Worm from a larger that lay dead by it, and put it upon a living one to which it immediately fastened, whilst the other at the same Time used all Means, by bending, stretching, contracting, and winding its Body, to free itself from this troublesome Guest, but in vain, the small one still keeping its Hold.

Fig. 102. exhibits a *Tonnekin*, which was a Worm but the foregoing Evening, and had cast off a very thin Skin, this also consisted of several Rings and Circles as when in the Worm State. The Feet and Joints there-

* *Ph. Transf. No. 269.* † *Arc. Nat. Epist. 136.*

of were very visible; A B and A C represents its two Antennæ; and although they were inclosed in a thin Membrane, yet all the Joints might be clearly seen. The Change of this Worm was so sudden, that Mr. *Leeuwenhoek* was never able to see it.

Not only the *Willows* and other *Trees*, but Plants also have Cafes produced on their Leaves, as *Nettles*, *Ground Ivy*, &c. by the Injection of the Eggs of an *Ichneumon Fly*. These Cafes are generally observed to grow near to some Rib of the Leaf, and their Production thus. The Parent Insect with its stiff setaceous Tail, terebrates the Rib of the Leaf when tender, and makes way for its Egg, into the very Pith or Heart thereof, and probably lays in therewith some proper Juice of its own Body to pervert the regular Vegetation of it. From this Wound arises a small Excrecence which (when the Egg is hatched into a Maggot) grows bigger and bigger, as the Maggot increases, swelling on each Side the Leaf between the two Membranes; and extending itself into the parenchymous Part thereof, until it grows as big as two Grains of Wheat; in this Case lies a very small white rough Maggot, which turns into a beautiful green small *Ichneumon Fly*.

S E C T. VIII.

Of the Crane-Fly, or Father Long-legs.

THIS little Creature, though but seldom taken Notice of, affords an agreeable Variety of Subjects, when examined by the *Microscope*. It is produced from a Worm hatched in an Egg, deposited by its Parent under the Grass in Meadows.

These Worms are to be met with but in the hot Weather upon the Ground under the Grass in the Meadows and Fields. Fig. 103. represents one of them, which could not be discerned to change or increase between the Months of *May* and *August*.* Fig. 104. shews the Worm changed into a Nymph, and at its first coming forth greatly agitated. Fig. 105. shews the cast-off Skin, which in its Change the Worm forsook, after which it took Wing and flew away in the Form of Fig. 106. which represents one of these male Flies, as does Fig. 107, also shew the *Female*.

The Tails both of the Male and Female are of a curious Structure, that of the Female is sharp, and of the Consistence of Bone, wherewith she perforates the Ground, and deposits her Eggs under the Grass in a moist Place. This acute Tail of the Female is shewn at N, Fig. 107. which she can open into four distinct Parts †. Upon opening one of these Females

* *Leeu. Ex. & Contemp.* p. 347.

† *Leeu. Ex. & Contemp.* p. 349.

Mr. *Leeuwenhoek* counted upwards of 200 Eggs of a blackish Colour and smooth, like polished Glass, and about twice as long as they were thick. The Intestines of this little Creature are also very curious, which when opened with unspeakable Admiration he saw them by the Assistance of the *Microscope*, as plainly as the Bowels in larger Animals can be seen by the naked Eye.

In the Feet of this Fly, if dissected in a Drop of Water upon the Glass R, Fig. 2. of the *Universal Microscope*, the fleshy *Fibres* may be seen to distend and contract themselves in a most surprising Manner, and to continue so for the Space of three or four Minutes. The Eggs also after Dissection may be applied to the said Glass, and easily examined by the Microscope, or on dipping the Point of a very fine sewing Needle (it being first fixed in a wooden Handle) into some Turpentine, and applying that to the Eggs, they will be glued thereto. The Needle itself must be held between the Nippers, and by its Handle may be turn'd round at Pleasure.

It is very wonderful how so small a Creature as some of those newly hatched Maggots, that are found in the Ends of blighted Leaves, can be able to convolve the stubborn Leaf, and then bind it with the Thread or Web it weaves from its own Body, also to line the Inside of it with the same, and stop up the two Ends thereof to prevent its own falling out.

In the Bodies of many *Caterpillars*, and other Nymphs of Insects, are frequently found to be generated great Numbers of small *Flies*, whose parent Animal had wounded the *Caterpillar* *, and darted its Eggs into it; and so made it the foster Mother of its young.

Some Insects lay up their Eggs in Clusters, as in Holes of Flesh, and such Places, where it is necessary they should be crowded together, which without doubt contributes towards the hatching †.

Other Insects observe great Order in the Disposition of their Eggs, which may be found upon the Posts and Sides of Windows, very neatly laid, being round and resembling small Pearl, which Eggs produce a small hairy *Caterpillar* ‖. The white *Butterfly* also lays its Eggs on Cabbage-Leaves, and always glues one certain End of them to the Leaf. If these Eggs be applied to the *Universal Microscope* on the Glass R, Fig. 2. you will find them curiously furrowed and handsomely adorn'd.

The *Pease Ichneumon Fly* § is very small, its Wings large, reaching beyond the *Podex*; Antennæ long, Alvus short, shaped like an Heart, with the Point towards the *Anus*, it walks and flies but slowly. No Tail appears, but they have one concealed under the Belly.

Ichneumon properly signifies the *Egyptian Rat* **, which has its Name from

* *Pb. Tb.* p. 390. † *Pb. Tb.* 393. ‖ *Pb. Tb.* p. 393. § *Pb. Tb.* 387.
** *Philos. Transf.* No. 77.

its hunting or tracing out the Eggs of Crocodiles and Asps: A like Observation made by some of the Ancients on certain Insects of the Wasp-Kind, occasioned the Application of that Name to Wasps, as well as the Egyptian Rat; there is but one Passage in all Antiquity concerning these Wasps, viz. in *Aristot. de Hist. Anim. Lib. 5. c. 20.* which *Pliny, Lib. 11. c. 21.* hath render'd thus, *Vespæ Ichneumones vocantur (sunt autem minores quam aliæ) unum genus ex aranes perimunt, phalangium appellatum, & in nidos suos ferunt, deinde illinunt, & ex iis, incubando, suum genus procreant;* that is, the Wasps, called *Ichneumons*, and which are smaller than other Wasps, kill a Species of Spiders, called *Phalangium*, and carry them to their Nests, after which they besmear them, and by Incubation produce their own Species out of them.

There is also a certain *black* and curious *Fly*, which proceeds from the gouty Excrescencies of the *Briar Stalk* *, with red Legs. Black, smooth jointed Antennæ, large Thorax, and Belly in the Shape of an Heart. It leaps like a Flea.

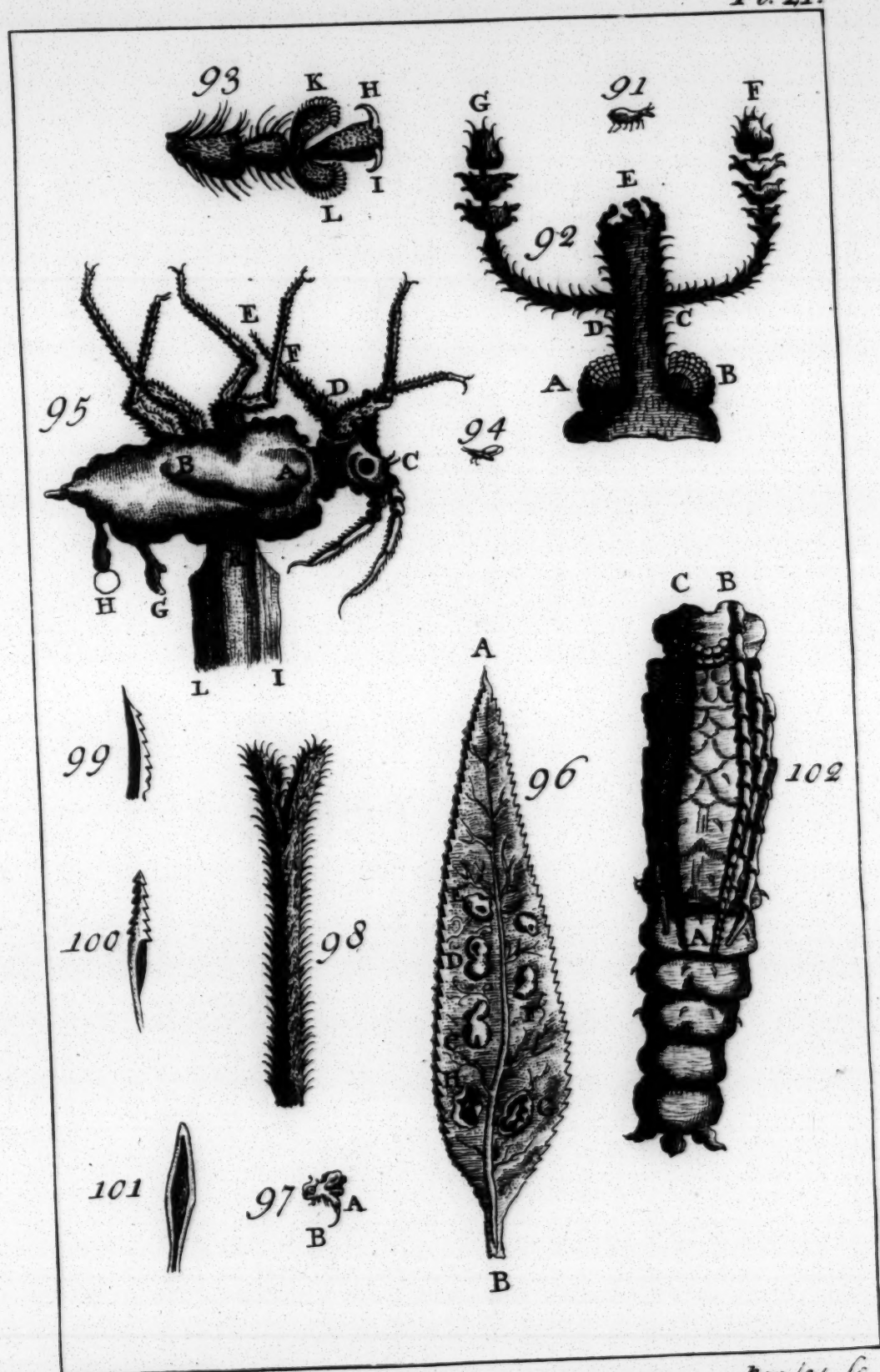
The *Excrescencies* of the Roots of *Cabbages*, *Turneps*, and divers other Plants, have always a Maggot in them, not yet sufficiently observ'd.

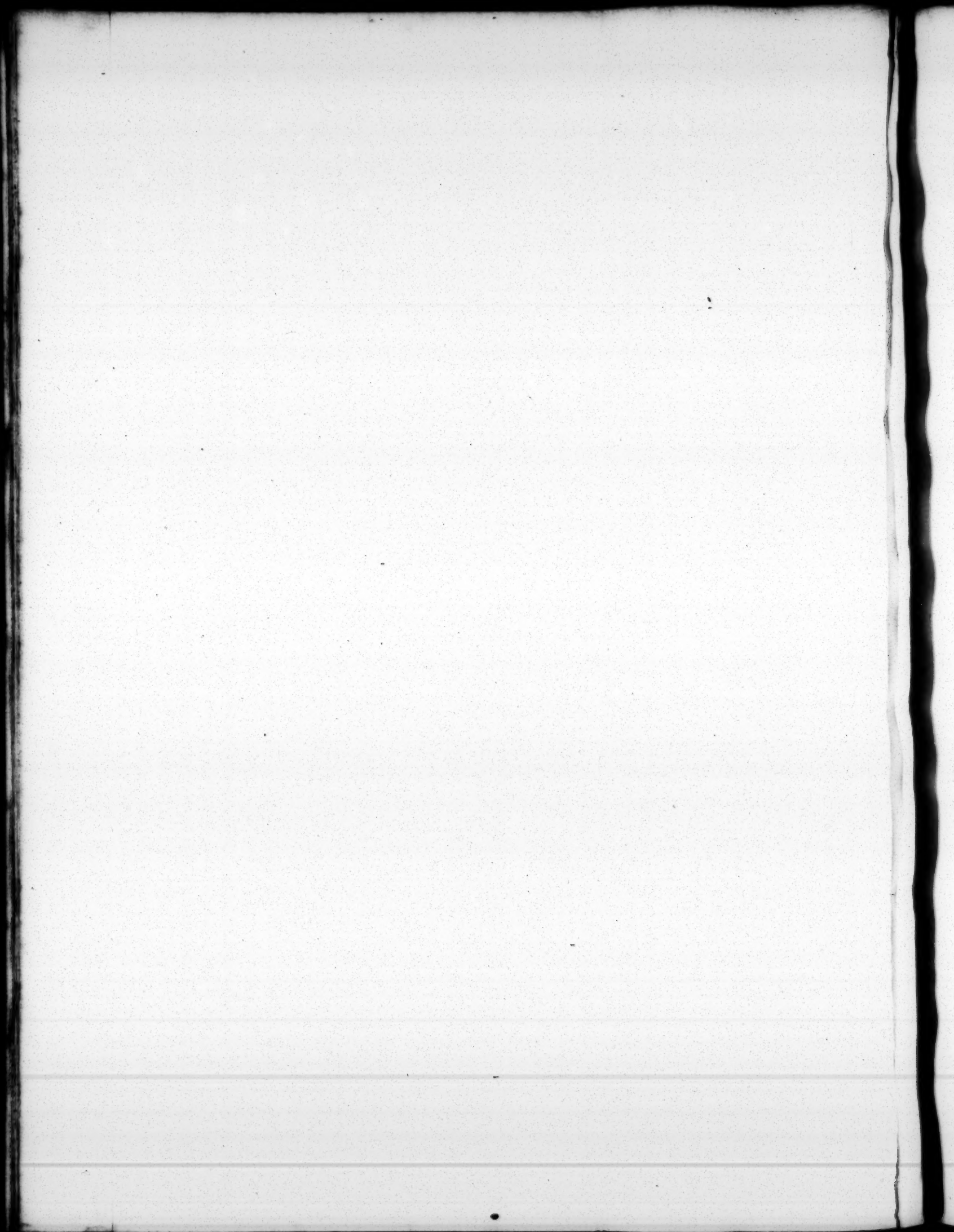
Caterpillars, and divers others Insects, can emit Threads or Webs for their Use. In this their *Nymph State*, they secure themselves from falling, by letting themselves down from the Boughs of Trees, and other high Places, with one of these Threads, and secure themselves in their *Aurelia State*, in Cases of their own Weaving.

Some of the *Fly Tribe* are also endowed with this textrine Art, of these one Sort spins a long milk white filken Web as big as the Top of one's Finger, woven round bent Stalks of *Ribwort*, &c. in Meadows. The other is a Lump of many yellow filken Cases sticking confusedly together on Posts, under *Coleworts*, &c. these Webs contain in them small whitish Maggots, which turn to a small *black Ichneumon Fly*, with long capillary Antennæ, tan-colour'd Legs, long Wings, reaching beyond their Body with a black Spot near the Middle, the Alvis like an Heart, and in some a small setaceous Tail. Some of these Flies are of a beautiful shining green Colour. The Flies coming from these two Productions are nearly alike.

Many of the *Ichneumon Wasps* † are remarkable for the Nidification and Provision of their Young. Those which commonly have golden and black Rings round their *Alvi*, line the Cells they perforate in the Earth, lay their Eggs therein, and then carry into them Maggots from the Leaves of Trees, and seal them up close and neatly; these Wasps have their Jaws not only very strong but nicely sized, curved, and set for gnawing, and scraping. Those little Holes they perforate in the Earth and Wood, as well as the se-

* *Ph. Th. p. 250.* † *Ibid. p. 228.*





veral Parts of the Wasp itself, are a pleasant Object for the Microscope.

The Bearers of Fruit-Trees are full of Asperities, and not so smooth on their Bark as the other Parts of the Tree are. If after Harvest, and any Time in Winter, you view these Bearers in the Microscope, their Cavities will be found to be full of Eggs, of an oblong Figure, and citron Colour, especially in those Years wherein the *Caterpillars* * have been numerous. Out of these they are hatched in the Spring. The Seasons which usually destroy them, are such as come in with early Heats, before the coming out of the Buds and Blossoms, and on which a nipping frosty Air ensues, which soon kills them.

S E C T. IX.

Of Oak Cones.

THESE Cones are to Appearance, perfectly like *Gems*, only bigger, being nothing else than these increased in Bigness, instead of Length. The Cause of this Obstruction in the Vegetation is this, into the very Heart of the young tender Gem or Bud, (which begins to be turgid in *June*, and to shoot forwards towards the latter End of that Month, and the Beginning of the next) into this Bud the parent Insect thrusts one or more Eggs, and perhaps not without some venomous † Ichon therewith; this Egg soon becomes a Maggot, and eats itself a little Cell in the very Heart or Pith of the Gem, which is the Rudiment of the Branch together with its Leaves and Fruit. The Branch being thus destroyed, or at least its Vegetation obstructed, the Sap that was to nourish it is diverted to the remaining Parts of the Bud, which are only the scaly Integuments, by this Means growing large and flourishing, becomes a Covering to the Insect Case, as before they were to the tender Branch and its Appendage.

The Case lying within this Cone, is at first but small, as the Maggot included in it is, but by Degrees, as the Maggot increaseth, it also grows bigger, to the Size of a small Pea, long and round, in the Shape of a long Acorn.

The Insect produced from these Cones, hath four membranous Wings, reaching a little beyond the Belly, articulated Horns, large Thorax, Belly short and conical, Legs partly whitish, partly black, of a beautiful shining green, in some tending to a dark Copper Colour.

The *Aleppo Galls*, wherewith we make Ink, are no other than Cases in which Insects breed, which when they come to Maturity, gnaw their Way

* *Philos. Transf.* No. 237. † *Pb. Tb.* p. 397.

out of them, which occasions those little Holes observable in them; See *Philos. Transf.* No. 245.

Of this Sort also are the little smooth Cases, about the Size of large Pepper Corns, which grow close to the Ribs, under oaken Leaves, at first of a blushing red, afterwards growing brown, hollow within, but an hard thin Shell without, in which commonly lies a rough white Maggot, afterwards transformed into a black *Ichneumon Fly*, that eats a little Hole in the Side of the Gall, and so gets out.

Some of these Balls are tender, as those of a yellowish green Colour with a reddish Cast, about the Size of a small Musket Bullet, growing close to the Ribs, under Oaken Leaves, their Skin smooth with frequent Risings therein, inwardly they are very soft and spongy; and in the very Center is a Case with a white Maggot therein, which becomes an *Ichneumon Fly*.^{*} This Gall is remarkable for the *Fly* lying therein all the Winter in its infantile State, and comes not to its Maturity till the following Spring. In Autumn and Winter those Balls fall down with their Leaves to the Ground, in which the inclosed Insect is fenced against the Winter Frosts, partly by other Leaves falling pretty thick upon them, and especially by parenchymous spongy Walls, afforded by the Galls themselves.

From the large Oak Balls, called *Oak Apples*, which grow in the Place of the Buds, out of these Galls, come another Species of *Black Flies*.

The gouty Excrescencies in the Body, and Branches of the Black-berry Bush, produce a small shining black *Ichneumon Fly*, about a Tenth of an Inch long, with red jointed Horns, four Wings, red Legs, and a short Belly. They hop like Fleas.

All these Insects afford an entertaining and agreeable Variety when viewed through a *Microscope*.

S E C T. X.

Of an Insect found upon the Leaves of Spices and in Woods of several Kinds.

MR. *Leeuwenboek* discover'd upon the Leaves of some white Nutmegs, an *Animalcule* or minute Worm, which appeared to the naked Eye of the Size of Fig. 108. but is represented in Fig. 109. as it appear'd when placed before the *Microscope*. Its Body was jointed in several Places, and thickly set with Hairs; it had six short Feet, which end with a shining Nail, toothed like a Saw, as at A, B, C, D, the hinder Part of its Body was very full of Blood Vessels, as appears at E, F, G, H.

^{*} *Pb. Tb.* p. 400.

At I K are two shining Horns jointed and beset with Hairs. At L are represented its Forceps, with which the Worm eats its Way into Leaves or Wood, &c. MN shew the two lesser Horns which adorn the Head of the Worm. This Worm after some little Time was changed into a flying Insect, as exhibited in Fig. 110. whereof LM, BN are its two Horns, which consisted of divers Joints and Hairs, BL its Eyes furnished with a Number of little *Lenfes*, as the Eye of the Drone Fly before described. It had also six Feet armed with *Talons*, as before shewn: These Legs had several Joints, and were cover'd with Bristles or Thorns, two of these Feet and Nails are shewn by the Letters CO, DP. DE, and KI represents the two Cases or Shields under which the Wings are folded. These Cases are most curiously adorned with strait Rows of Rings throughout their whole Length. The hinder Part of its Body is jointed as it were with hollow Notches, much after the same Manner as the Worm from which it was produc'd. If the Wing be considered, it will be found to consist of several small Vessels or Nerves that assist in the Expansion thereof. The exquisite Neatness with which this minute Wing was folded under the Shields, is surprizingly beautiful, as appears between GH, with what wonderful Nerves must these minute Wings be strengthened, that can enable this Insect so readily to fold up the Extremity of this filmy Membrane in so neat a Manner, and to expand it again, as it were instantaneously, whenever it is inclined to fly? That the curious Folding of these sort of Wings might be comprehended, Mr. *Leeuwenhoek* took off one of the shelly Cases and placed the Wing before the Microscope, which appeared as in Fig. 111. QST V W X Y represent the Wing as it lay cover'd under its Shield. It was broadest about V; the second Wing, which I suppose to be its Ballance or Poize, is shewn at ST. The Extremity W X Y, shews those neat Foldings before spoken of, which, together with the Strength of the Nerves, discover the Almighty's Wisdom in their Contrivance.

I have found of these Insect Flies in Summer-time flying about my Work-shop, and have observed them to answer all the above Description. They are so small, that I have applied them to the Microscope in the Ivory Sliders, but they are better seen when applied in the Nippers V, of Fig. 2.

There is likewise a small *Scarab* in the very Tips of *Elm-Leaves*. * In the Summer many of these Leaves may be observed to be dry and withered, and also turgid, in which lies a dirty, whitish, rough Maggot, from which proceeds a *Beetle* of the smallest Kind, of a Weefel-Colour; it leaps like a *Grashopper*, although its Legs are but short, black Eyes, *Vaginæ* thin, and prettily furrow'd, with several Cavities, small duded *Antennæ*, and a long *Proboscis*.

* *Ph. Theo.* p. 251.

The same, or one much like this is found on the Tips of *Oak* and *Holly Leaves*.

The *Horse-Fly* is also a curious Object, its Eye is in the Form of other Flies, but is as it were indented all over with a pure emerald Green, its Body like Silver in Frost-Work *, fringed all over with white Silk. If the Head of this Fly be cut off just at the setting on of the Neck, a pulsing Particle may be seen beating through the Skin for half an Hour together.

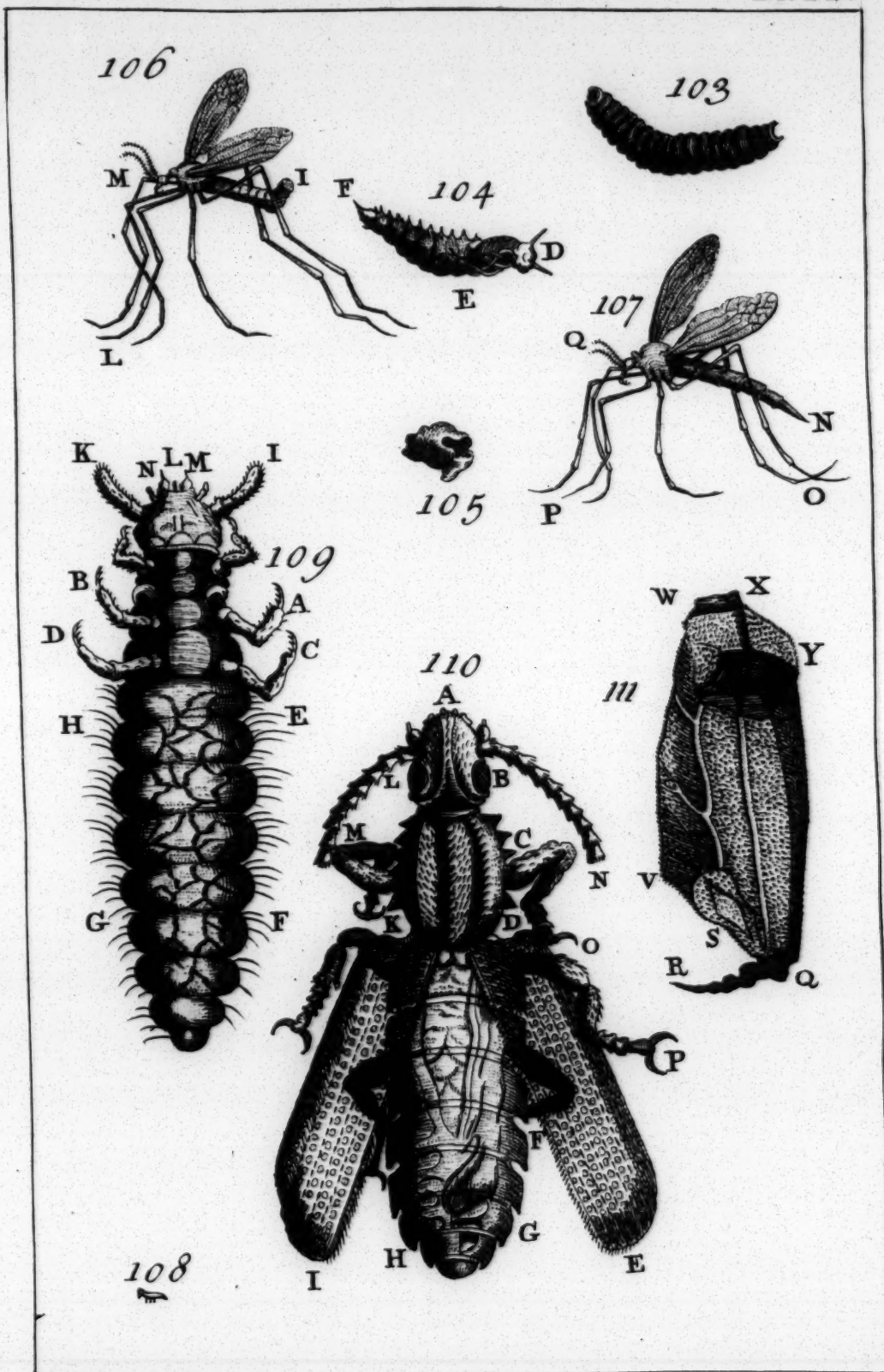
The *Trunk* or *Proboscis* of a *Butterfly*, which lies wound up like an Helix or spiral Spring, gradually growing slender as at Fig. 113, supplies the Office both of Mouth and Tongue, it may with a Pin be easily drawn out to its full Length, if it be cut off and laid upon the Object carrying Glass R, of Fig. 2. and so applied to the Microscope you will see it wind and coil † itself up, and then to open itself again for a long Time together, Nature having made it of a sufficient Length, that when extended it may reach into the Hollows of Flowers, and from thence extract their Dews and Juices. It consists of two Tubes near its Extremity, as represented at A C, Fig. 113. the Cavities of which unite at D, and from thence to the Throat of the *Butterfly* form but one Channel ‖. These tubular Extremities are unfolded in the Manner expressed at B T N, Fig. 114. in order to extract the Dews, &c. from Flowers; after which it is immediately drawn back and coil'd up into an Helix. M M, Fig. 115. represents one of the extreme Parts viewed with a greater Magnifier, and delineated exactly in the Manner as it is applied to Leaves and Flowers. Whence it appears, that it is not the extreme End of the Proboscis, which extracts the Dews and Juices; but several Nipples D E F, that are applied to the Leaf A C, at the Points i i i.

In all *Grashoppers* there is a green Film or Plate (like a Croslet) which covers the Neck and Shoulders; if you raise it up with a Pin you may see their *Heart beat* § for a long Time together. The *Grashopper* is best held between the Nippers V, and so applied to the Magnifier.

There is a pretty Object, which is a white oblong Insect that sticks to the Back-side of *Rose-tree Leaves* ** in *August*, of a perfect white, it changes into a small yellow Locust, with two white Wings longer than its Body, and two Pointers in the Snout like a Pair of closed Compasses, and may be plainly seen when the Fly is laid upon its Back.

Upon the Backside of the Leaves of *Gooseberries*, *Sweet Briar*, and *golden Mouse-ear* in *April* and the Beginning of *May*, is a greenish *Grashopper* or *Locust* ††, which is a pleasant Object; when placed before the *Microscope* it hath two Horns and four Legs, and two curious black Eyes.

* *Power's Micro. Obs.* p. 7. † *Ibid.* p. 8. ‖ *Microgra. de Bonan. Pars 2.* p. 48. § *Power's Micro.* p. 24. ** *Ibid.* p. 27. †† *Ibid.* p. 26.





On *Sycamore Leaves* there is a yellow Insect *, which at first hath no Wings, but six Legs and two Horns which are slit; it runs nimbly, the Eyes are globular and red, pearled and prominent; near the Shoulders are two Stumps, whence two long Wings come forth, when it changes into a Fly or Locust, it consists of annular Circles, and is hairy towards the Tail.

There is to be found a small long black Insect, creeping and leaping amongst *Pinks*, *Gilly-Flowers*, *Rose-leaves*, &c. with a *Wasp-like Body*, with six or seven annular Divisions; two curious Horns arising from a black knobbed Root, two fine long yellow Wings, black Eyes, and six black Legs, they are kill'd with the least Touch imaginable; their Size is less than that of a Louse: * They may be taken up with the Point of a Pin dipped in Spittle, and by that Means placed, or as it were glewed to a very small Bit of Card, which may be applied to the Microscope in the Nippers of Fig. 2. And stronger Insects may be stuck to a larger Piece of Card with a Touch of Turpentine, and applied to the Magnifier in the Nippers as before.

On the *Froth*, which hangs on the *Leaves* of *Lavender*, *Horfe-mint*, *Rosemary*, &c. || (by some called *Cuckow-spit*) is always found a little Insect of a golden Colour; it hath six Legs, with two black Claws at the End of each, which it can open and shut at Pleasure; its Eyes are pearled and of a dusky Red, a long reddish Proboscis is situated between its fore Legs; its Tail had several annular Divisions that ended in a Stump, which it could at Pleasure thrust out or draw back, it first creeps, then leaps, and at last flies.

The *Cow-lady*, *Lady-bird*, or *spotted Scarabee*, is a very nimble Animal; cut off its Head, and erect it perpendicularly upon the Neck (which may be fastened to a Bit of soft Wax first stuck upon the Point, or by a Drop of Gum-Water upon a Piece of Card, which may be held in the Nippers, and so applied to the Microscope) and you'll see two small black Eyes set upon three white Plates like polished Ivory, two small ones on one Side, and a large one on the other; pull off both the crustaceous and filmy Wings, which are a Fence to a thin tender black Skin, under which the *Pulsation* of the Heart § may be seen to beat vigorously for 12 or 14 Hours, after the Head and Neck are separated.

There is a *Fly* with grey and black *Streaks* on the *Shoulders* **, and *chequer'd* on the *Tail* with the same Colours; upon opening the Female of this Fly, which may be distinguished by a Redness on the Extremity of the Tail, you will find two Bags of live white Worms **, long and round in Shape, with black Heads, moving both on the Hand and in the unopened Vesicles

* *Power's Mi. Ob.* p. 32. † *Ibid.* p. 31. || *Ibid.* p. 28. § *Ibid.* p. 30. ** *Phi. Transf.* No. 72.

backwards and forwards, being disposed in Cells according to the Length of the Animal's Body.

S E C T. XI.

Of the Cochineal Fly.

THE *Microscope* hath discovered to us that *Cochineal*, so valuable for its Use in dying *Crimson*, *Scarlet*, and *Purple*, is an Insect bred upon the Plant called *prickly Pear*, or *Indian Fig* †; and upon the Leaves or Twigs thereof are small *Knobs* or *Protuberances*, which produce little Worms that in Time become Flies, resembling *Cow-ladies*, or *Lady-birds*; which, when arrived at their full Growth, are taken by the Inhabitants (of the Islands of *Cuba*, *Hispaniola* and *Jamaica*, from whence it most commonly comes) and exposed to the Heat of the Sun to dry, and rubbed between the Hands till their Wings, Legs, &c. fall off. Upon steeping some of the Grains of *Cochineal* 24 Hours in Water, a Trunk with Scales and Legs will appear; and if their Bodies be opened, many Eggs of different Sizes may be also found.

Fig. 116. represents a Grain of *Cochineal*; Fig. 117. another Grain, as it appear'd through a *Microscope*, in which at the extreme Parts C and E F, an Orifice appears, from whence the String was broken off, whereby both Parts of the Body were joined together. The concave Arches D G, &c. are not natural, but adventitious to the same Grain, proceeding only from the drying or shrinking up of the great Number of Eggs that lie within the *Animalculum*; for if the same Grain was well soaked in Water, the concave Parts would become convex. Fig. 118. shews an Egg with its Membrane, as it was taken out of a Grain of *Cochineal* steeped in Rain-Water for about 24 Hours; in which might be seen the young one, and its Shell surrounding it. L M N, Fig. 119. represents one of these unborn *Animalcula*. Fig. 120, shews the Body of another *Animalcum* which was taken out of the Egg-shell, in which not only the Body was distinctly seen, but also the Parts thereof divided into several Circles, and likewise the two Horns with the Joints wherewith Nature hath provided all those unborn *Animalcula*, were plainly visible when placed before the *Microscope*. B H, D I, and D K, shew its four Legs, the other two being hid from the Sight. F G represent the Horns, at the Extremity of each of which are three small Hairs.

† *Phi. Transf.* No. 292.

S E C T. XII.

Of the Death-watch.

THERE are two kind of Insects which make a regular clicking Noise like the Beats of a Pocket Watch; one of them called by *Swammerdam*, *Scarabeus Sonicephalus*, and the other called by *Mr. Derham*, *Pediculus Pulsatorius*.

The first of them is a small *Beetle*, about $\frac{5}{16}$ of an Inch in Length, * of a dark brown Colour, with Spots somewhat lighter irregularly placed. It is represented of its natural Size at Fig. 121. Under its Vaginæ are pellucid Wings, the Head large, by reason of a Cap or Helmet which covered it, only a little turned up at the Ears; under this appear'd its Head, which was flat and thin, the Eyes forward, the Lips hard and shining, the Bars of the Helmet greyish; two Antennæ proceeded from under the Eyes, the Head all hairy, and Face thick of curled Hair; on the Belly was a little Hair, but thinly set; its Eyes like those of a Fly. Fig. 122. is a Microscopick Picture of it; between the Eyes the Face rises in a little Ridge, which is the Nose; and just below it the Nostrils are covered with strait pendulous Hair, the Lip-shades shew the more depressed Places; under this Lip are four visible Forceps, two on each Side to lay hold on its Food. They make a Noise just like the Beats of a Pocket-Watch. *Mr. Derham* has often caused one of them to beat when he pleased by imitating its Beating, and this he kept in a little Box about three Weeks; and imagines, that these Pulsations is the Way these Insects woo each other, and invite to Copulation; and that it always draws back its Mouth, and beats with its Forehead †.

The other *Death Watch* is an Insect different from the foregoing, that beats only about seven or eight Strokes at a Time, whereas the former will beat some Hours together without Intermision, and its Strokes slower, and like the Beats of a Watch. It is a small greyish Animal, much resembling a Louse; for which Reason it is called *Pediculus Pulsatorius*. It is very nimble, but extremely shy when disturbed; it will beat freely enough before you, and also answer you when you beat, if you can view it without giving it any Disturbance, or shaking the Place whereon it lies. It is not certain whether they beat on any other Thing but Paper, their Noise being heard only in or near it.

Fig. 123. represents the second Sort of *Death Watch* ||, as it appears to the naked Eye. Fig. 124. shews it a little magnified; its Shape and Colour

* *Phil. Transf. No. 245.*† *Phil. Transf. No. 271.*|| *Phil. Transf. No. 291.*

is not much unlike a Louse; it is common in most Houses in the warm Months, but in the cold Season of the Year it hides itself in dry obscure Places, and is seldom seen; some Time after Copulation, they lay their Eggs in dry dusty Places; they are much more minute than the Nits of Lice, of a whitish Colour, and are hatched by the Warmth of the approaching Spring, which to them is all the same as an Incubation: The Insect is fully hatched, and can creep about at the Beginning of *March*, or sooner if the Weather be warm; at their first quitting the Egg-Shell, they are so exceeding small, as scarce to be discern'd, without the Assistance of a convex Glass: In this State Mr. *Derham* could find no other Difference between them and Mites in Cheese, when viewed with a Microscope that magnified much, but only that Mites had more Bristles about the Breech: In this Shape they continue six Weeks or two Months, feeding on divers Things they can meet with; after which they gradually increase towards their more perfect State, when they become like the old ones.

Mr. *Derham* has plainly shewn, that their ticking Noise is a wooing Act, and that it is commonly about *July*; * he never found them in *Coitu*, till about a Week or a Fortnight after their ticking; tho' it is probable they copulate at that very Time. He has seen the old *Death Watches* feed upon dead Insects, as the young ones do, and also upon Biskets, Tallow, &c. nay Dust itself, and hath observed them thro' a Microscope to select some Grains thereof, and reject others.

C H A P. XVIII.

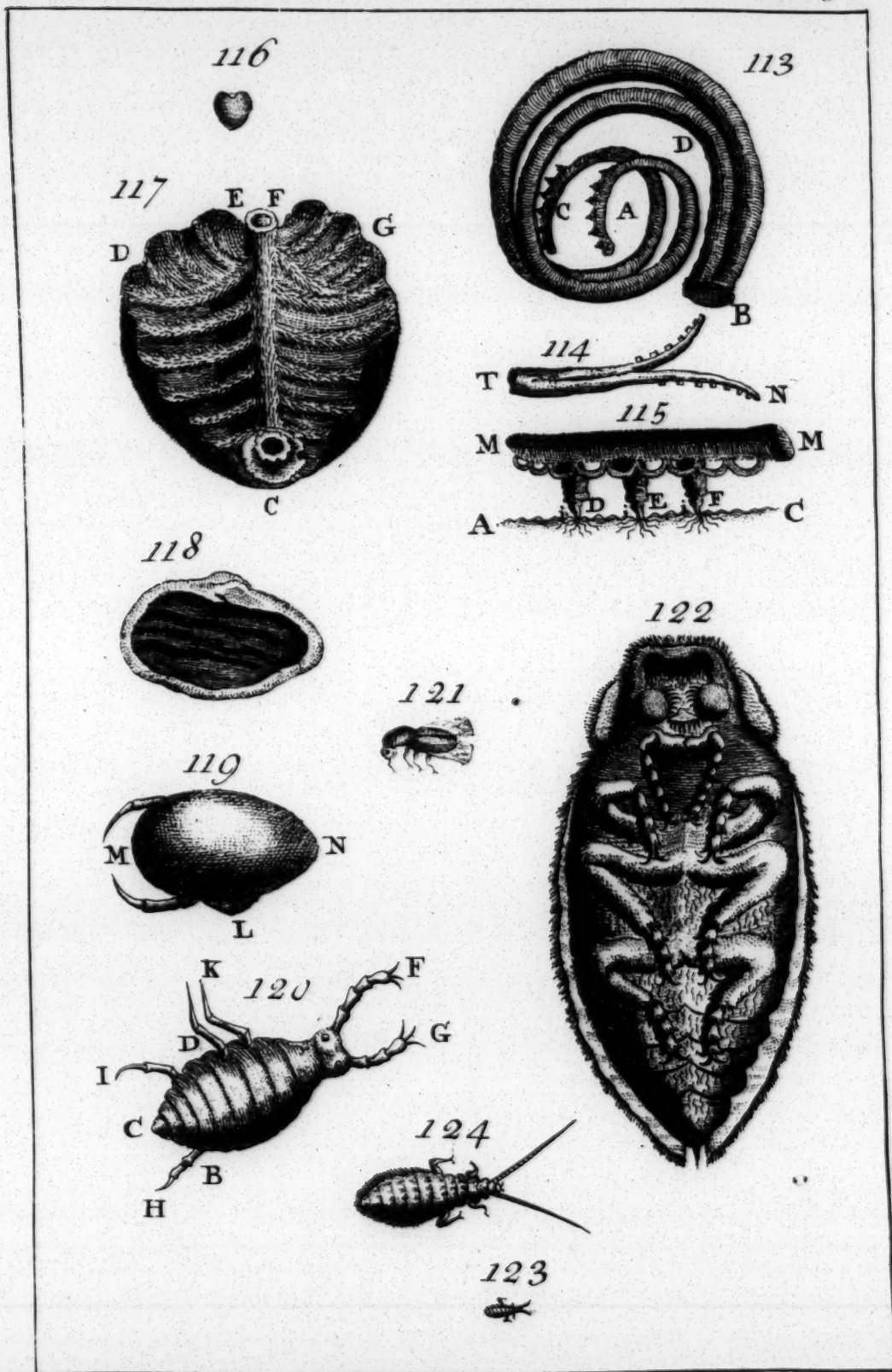
Of a Gnat.

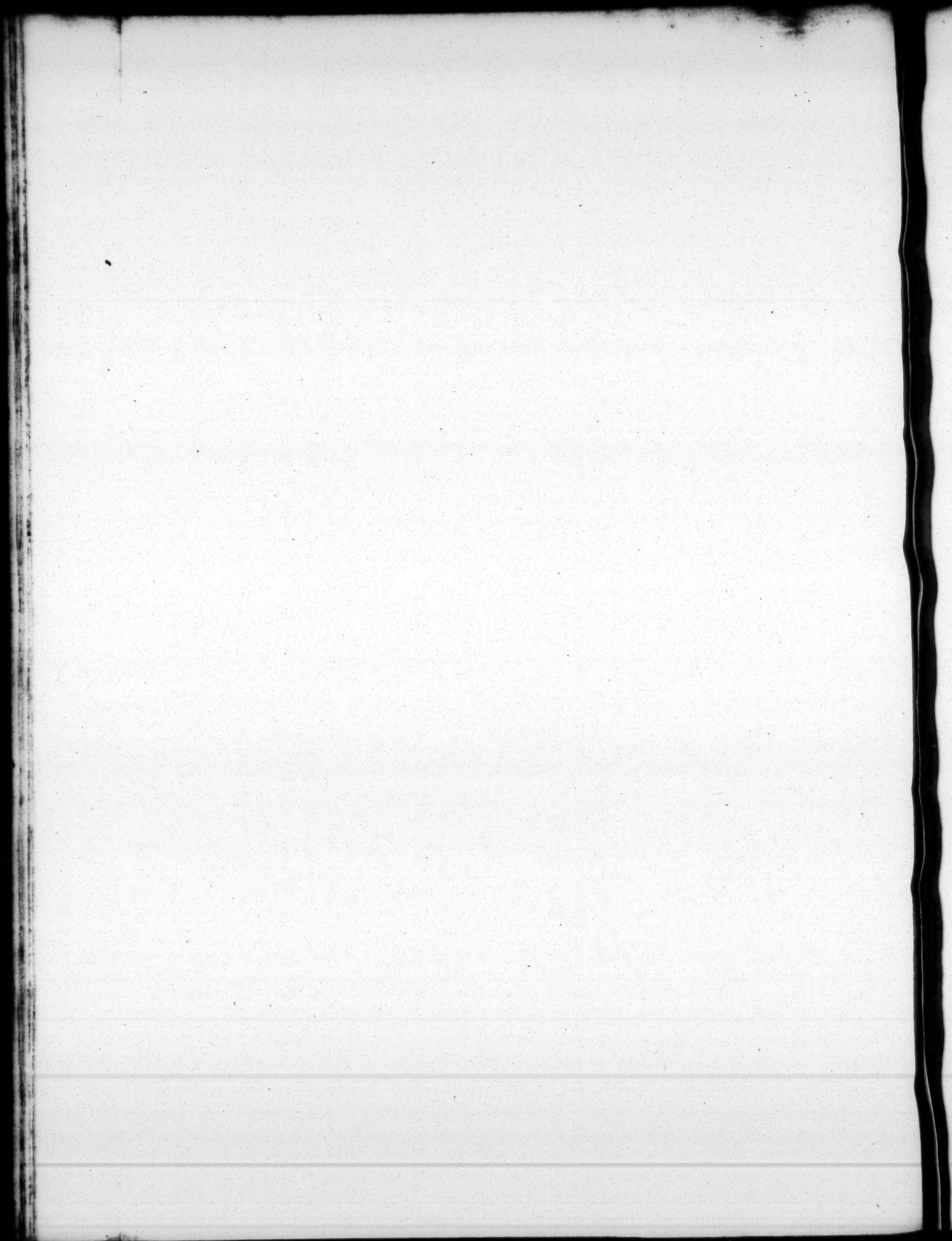
S E C T. I.

THE first observable in the Generation of this Insect, is its vast Spawn, some of them being $1\frac{1}{2}$ Inches long, and $\frac{1}{8}$ of an Inch broad, floating in the Water, but being made fast to something to prevent its being washed away; in this transparent Spawn the Eggs are neatly deposited, in some a single, in others a double spiral Line †, running from End to End, as in Fig. 125, and 126. and in some transversely, as in Fig. 127.

When the Eggs are by the Heat of the Sun, and Warmth of the Season, hatched into small Maggots, these Maggots descend to the Bottom; and by Means of some of the gelatine Matter of the Spawn, which they take along with them, they stick to Stones, and other Bodies at the Bottom,

* *Phil. Transf.* No. 271. † *Phi. Theo.* p. 394.





and there make themselves little Cafes or Cells, which they creep into, and out of at Pleasure, till they arrive at a more mature Nymph State, and can swim about here and there in Quest of Food; at which Time they are a Kind of red Worms about half an Inch long, but of the Shape of Fig. 128.

It has a very large Head, in Proportion to its Body, which is all covered with a Shell; several Tufts of Hair on several Parts, two Horns, a large Mouth, &c. The Form of the whole Creature will be better perceiv'd by a Description of Fig. 128. the hinder Part or Belly consists of eight several Joints. From the Midst of each of which, on either Side, issue out three or four small Bristles. The Tail was divided into two Parts, very different in Make; one of them A, had several Tufts of Hair or Bristles, with which it could steer itself as it pleased, and was enabled to swim about by Curvations and flapping its Body sideways, this Way and that, and keep itself near the Surface of the Water: The other Part B appeared to be the ninth Division of its Body, and on each Side had many single Hairs. From the Part C to the Head, appeared a darkish colour'd Gut, through which the peristaltick Motion was very discernable. The Chest D E of this Creature, was thick and short, and so transparent, that its white Heart could be seen to beat: Its Chest was stuck with several Tufts or Bristles, and the Head was also adorn'd with the same, it had two black Eyes, and two small Horns F G.

Both the Motion and Rest of this Creature are surprizing and pleasant. The Tail seems much lighter than the rest of its Body; and being a little lighter than the Water in which it floats, buoys it up to the Top thereof, where it hangs suspended with its Head downwards; they lift their Heads sometimes into the Air, at other times plunge them into the Water, their Tails all the while sliding along its Surface.

After having lived in this Manner the Time which Providence has allotted them, a stranger Change succeeds; they appear in Form of Fig. 129. and then they cast off their whole Skin, Eyes, Horns, and Tails; and issue forth as Insects of a quite different Element: The most beautiful and elegant Plumage adorns their Heads; their Limbs are of the finest Texture; their Wings are curiously fringed and ornamented; their whole Bodies are invested with Scales and Hair; and they are actuated by a surprizing Agility; in short, they become *Gnats*, and spring into the Air; and what is most amazing, a Creature, that but a Minute since was an Inhabitant of the Water, would now be drown'd if it were plung'd therein.

It is very probable, that many Sorts of the Animalcules in Fluids undergo some such like Change.

S E C T. II.

Of the Tufted, Brush-horn'd, or Male Gnat.

ITS surprizing and particular Beauties are only to be discover'd by the MICROSCOPE; and is exactly of the Shape of one of those which Mr. *Hook* observed to be generated out of one of the little watery Insects just described.

Nature has adorned it in a most surprizing Manner: Its Head *A* is exceeding small in Proportion to its Body, which consists of two Clusters of pearled Eyes, Fig. 130. curiously ranged like those of other Flies; between which, upon two blackish Balls, are placed two long jointed Horns *D*, tapering towards the Top; from whence issued out in a circular Manner, Multitudes of small stiff Hairs from its several Joints, exactly resembling the Sproutings of the Herb *Horfe-Tail*. There are also two other jointed and bristled Horns or Feelers *D*. And a Proboscis *F*, underneath which is the Sucker or Sting, which in some *Gnats* is very long. This small Head, with its Appurtenances, is joined by a short Neck to the Thorax *G*, which is large, and as it were cased with a black Shell; out of its under Part proceeded six long slender Legs *H H*, &c. much like those of other Flies, but longer and slenderer, which are not expressed in the Figure, because of their great Length. From the upper Part proceeds two long slender transparent Wings, shaped somewhat like those of a Fly; underneath which, as is observable in many Sorts of Flies, are placed two small Bodies, which are its Ballances or Poises. Its Belly large, and extended into nine Partitions, each being armed with Rings of Shells; six of which were so transparent, that the peristaltick Motion was plainly visible. A small clear white Part at *I*, seem'd to beat like the Heart of a larger Animal; the three last Divisions of the Tail were cover'd with opake Shells.

S E C T. III.

Of the great belly'd or Female Gnat.

ALthough this *Gnat*, as represented in Fig. 131. differs from the former in Shape, yet this Sort also has been found to be generated out of the Water Insect before described: Its Wings were larger than those of the other; its Belly bigger and shorter; its Thorax not much unlike that of the other, having a strong rigid back Piece and Breast Plate; its Head larger and neater shaped; the Horns, that grew out of those two little Balls,

Balls which were between its Eyes, was of a different Shape from the Tufts of the other Gnat; these having but a few Knots or Joints and a few short Bristles; the foremost Horns or Feelers like those of the former.

In different Species of *Gnats* their Wings are also different; some having a Border of long Feathers, others of short ones, and others none at all: The Rib-work of the Wings is feathered in some and scaled in others, and in some beset with Prickles.

Mr. *Hook* suffered one of these *Gnats* to pierce the Skin of his Hand, and thence to draw out its Fill of Blood, which made it appear very red and transparent, and this without any further Pain, than whilst the Sting was entering; a good Argument that these Creatures do not wound the Skin out of Revenge, but for mere Necessity to satisfy their Hunger.

This Piercer, Sting or Sucker, as represented by F G H I, Fig. 132. is a Case cover'd with long Scales and Hairs; it lies concealed under the *Gnat's* Throat, when not made use of; but when it is, the Side G H opens, and four Darts are thrust out therefrom occasionally; one whereof H K (minute as it is) serves for a Case to the other three; the Sides of which towards the Point K are barbed or indented. F I shew that Part of the Sting where it was cut off from the *Gnat's* Throat.

Fig. 133. represents Part of the second Sheath, whose Sides near the Top are barbed, but not here expressed. This also opens Side-ways for a Passage to the three included Stings.

Fig. 134, shews all the Parts of the Stings wherein two of the interior ones might be seen barbed and indented towards the Point; their Fineness is almost inexpressible, they have three Sides, as represented in Fig. 135, whose Edges seemed to join alternately (which when so united resemble a three edged Sword, or Dagger.) Fig. 136, shews another Part of one of those interior Stings, which is remarkably small and somewhat curved. Its Top on the plain Side is shewn at Fig. 137. which Top is represented in another Position, Fig. 138. A. and in the Position of B its Hooks might be seen. When these Darts are thrust into the Flesh of Animals either successively or in Conjunction, the Blood and Humours of the adjacent Parts must flow to, and cause a Tumour about the Wound, whose little Orifice being closed up by the Compression of the external Air can afford them no Outlet. When a Gnat finds any tender juicy Fruits, or Liquors, she sucks up what she likes through the outer Case, without using the Darts at all; but if it is Flesh, that resists her Efforts, she stings very severely, then sheaths her Weapons in their Scabbard, and through them sucks up the Juices she finds therein. Upon Dissection many curious Things may be discovered, viz. numberless Animalcules in the Semen of the Male *, and in the Female a surprizing Quantity of Eggs.

* *Arc. Nat. Tom. IV. p. 22.*

There is a kind of *Gnat* which lays its Eggs frequently in dead Beer, &c, and some Time after this the Maggots are so numerous, that the whole Liquor seems to be alive, being full of Maggots; the larger Sort being the Offspring of this Gnat*; and the smaller that of a small dark coloured Fly, tending to a reddish Colour, frequent in Cellars and such obscure Places; they turn to Aurelia, and the larger Sort from that to a Gnat of a brown Colour. The chief Difference between the Male and the Female is, that the Male is least, hath a slenderer Belly, and its Podex not so sharp as the Female's is. This Gnat hath no Spear in its Mouth.

These Insects may be applied to the *Universal Microscope*, by pinching them between the Nippers, or sticking them upon the Point; their Stings when cut off may be best examined upon the Glass R of Fig. 2., when placed between the Object-Plate and Springs.

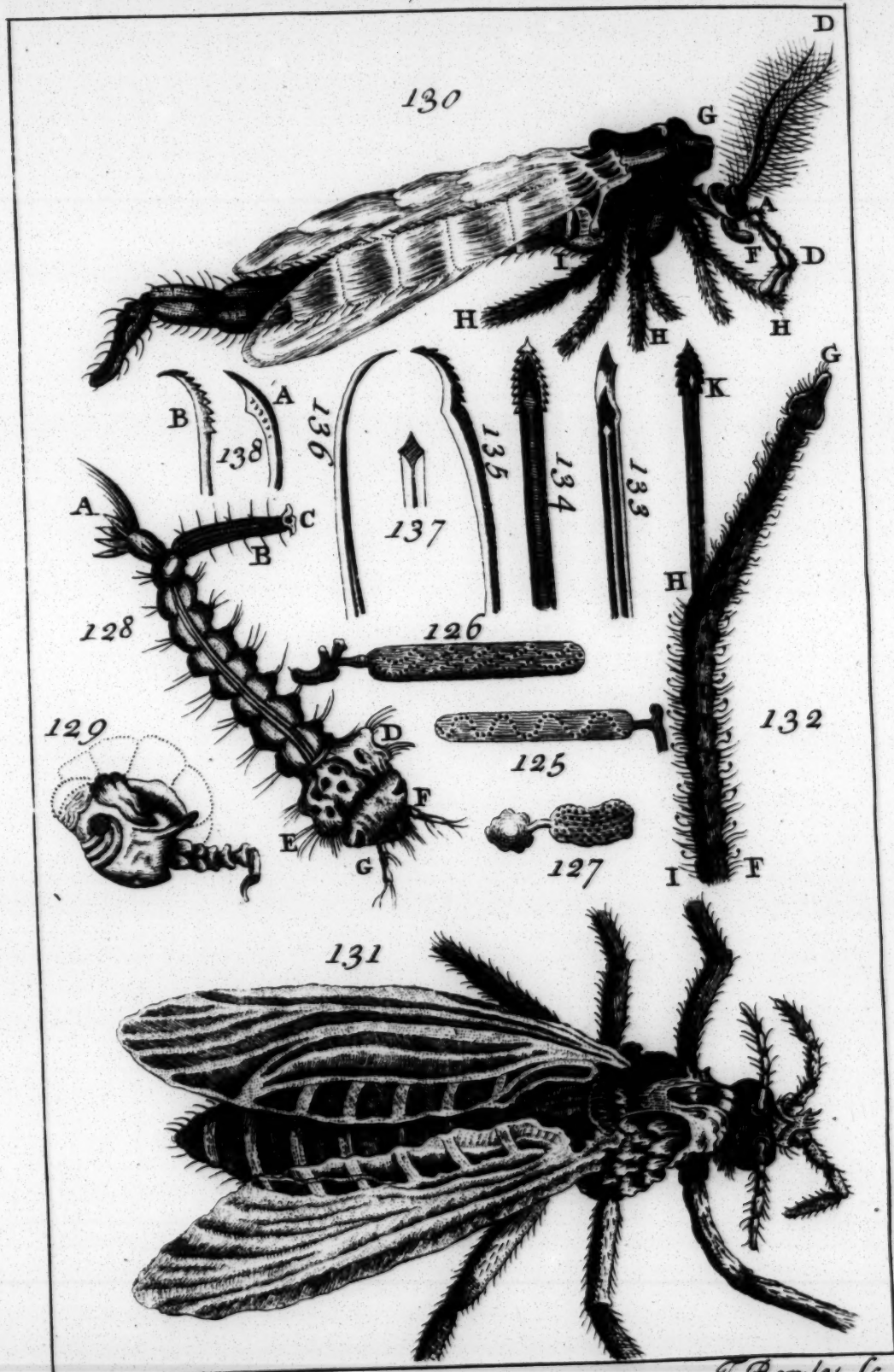
C H A P. XIX.

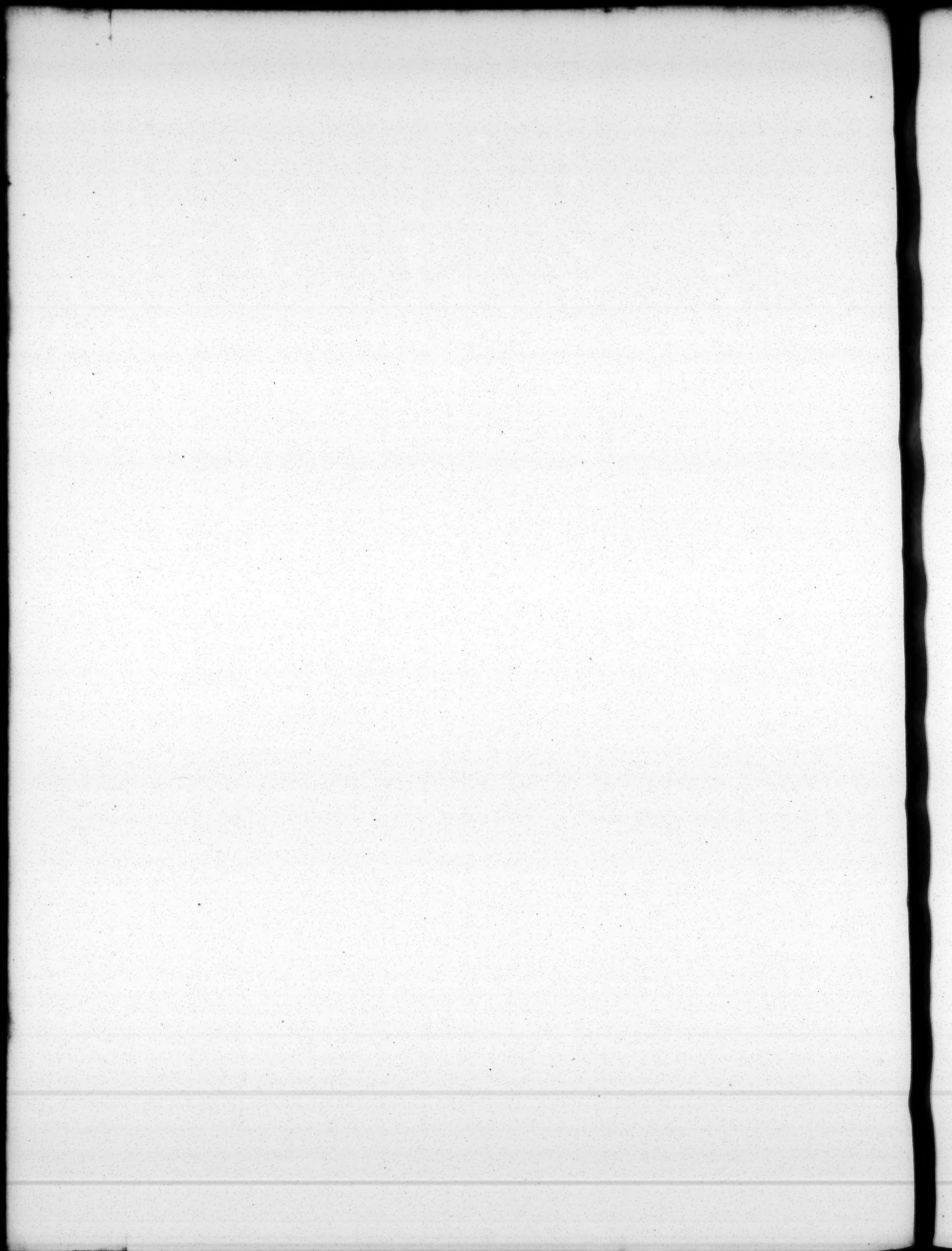
Of the white feather'd winged Moth.

S E C T. I.

IT appears to the naked Eye to be a small milk-white *Fly* with four Wings, the two foremost somewhat longer than the hindmost, and these about half an Inch in Length, each of these Wings consists of two Feathers, as represented in Fig. 139, very curiously tufted or hair'd on each Side, with exceeding white but minute Hairs; its whole Body, Legs, Horns, and Stalks of the Wings were cover'd over with various Kinds of white Feathers, which rub off between the Fingers when touched. Underneath these Feathers this curious Insect was covered all over with a crufted Shell. It had also different Feathers, that covered several Parts of its Body; the Tufts or Hairs of its Wings, when viewed in the Microscope, appear as represented in the Fig. by D. The Feathers which covered a Part of its Body, like A, consisting of a Stalk and a seeming Tuftedness on each Side; others which covered some Part of its Body, and the Stalks of its Wings much like Fig. B, those which covered its Horns and the smaller Parts of its Legs, in the Shape of Fig. C. Mr. *Hook* observed, that the smooth winged Insects have the strongest Muscles; and even this very Insect had a very small Body, if compar'd to the Length and Number of his Wings; which therefore as he moved them very slowly, consequently moved them as weakly; which last Property is in some measure observable

* *Pb. Theo.* p. 386.





in the larger Kind of flying Creatures, as Birds, &c. So that by the Assistance of the *Microscope* we find, that the Wisdom and Providence of the all-wise Creator, is no less shewn in those despicable Creatures, Flies, Moths, &c. than he is in the larger Parts of the Creation.

These little Animals may be pinched in the Nippers, or stuck upon the Point, and so applied to the Microscope; and its Feathers may be placed between two *Muscovy* Talcs.

S E C T. II.

Of the Wolf, or small Moth.

THIS *Insect* is a little *white Worm*, which infects *Granaries* and *Corn-Chambers*. In its perfect State it is really a *Moth*, of the Size and Form represented at Fig. 140. it has four whitish Wings spotted with black Spots.

When in the Reptile State, it appears as represented under Fig. 141. a magnified Representation of which is seen at K L, the fore Part of its Body had six Feet, which were not discernable till the Worm was turned on his Back, with its Belly upwards in this Position, Part of its Body is represented at M N, Fig. 146. wherein its six Feet may be seen. As it creeps along, an exceeding fine Thread or Web issues from its Mouth, by which it hangs to every Thing it touches, its Mouth is armed with a Pair of reddish Forceps, wherewith it gnaws its Way, not only into Wheat, and other Grain, but even perforates into Wood, and almost any Thing it meets with.

In these *Corn-Chambers* that are infested with this Vermin, they may be seen near the Decline of the Summer, crawling up the Walls in great Numbers, searching out for Places where they may abide in Safety, during their Aurelia State: For when the Time of undergoing a Change into that State approaches, they forsake their Food, and those little Cells they had formed of hollow'd Grains of Corn, clotted together by Means of the Web coming from their Mouths; and wander about till they find some wooden Beam, or other Body to their Mind, into which they gnaw Holes with their sharp Fangs, capable of concealing them; and there envelope themselves in a Covering of their own spinning; where they soon become metamorphosed into dark colour'd Aurelias *, and continue so all the Winter unactive and harmless: But about *April* or *May*, as the Weather grows warm, they are transformed into *Moths* of the Kind before described. Then are they to be seen in great Numbers taking little Flights, or creeping

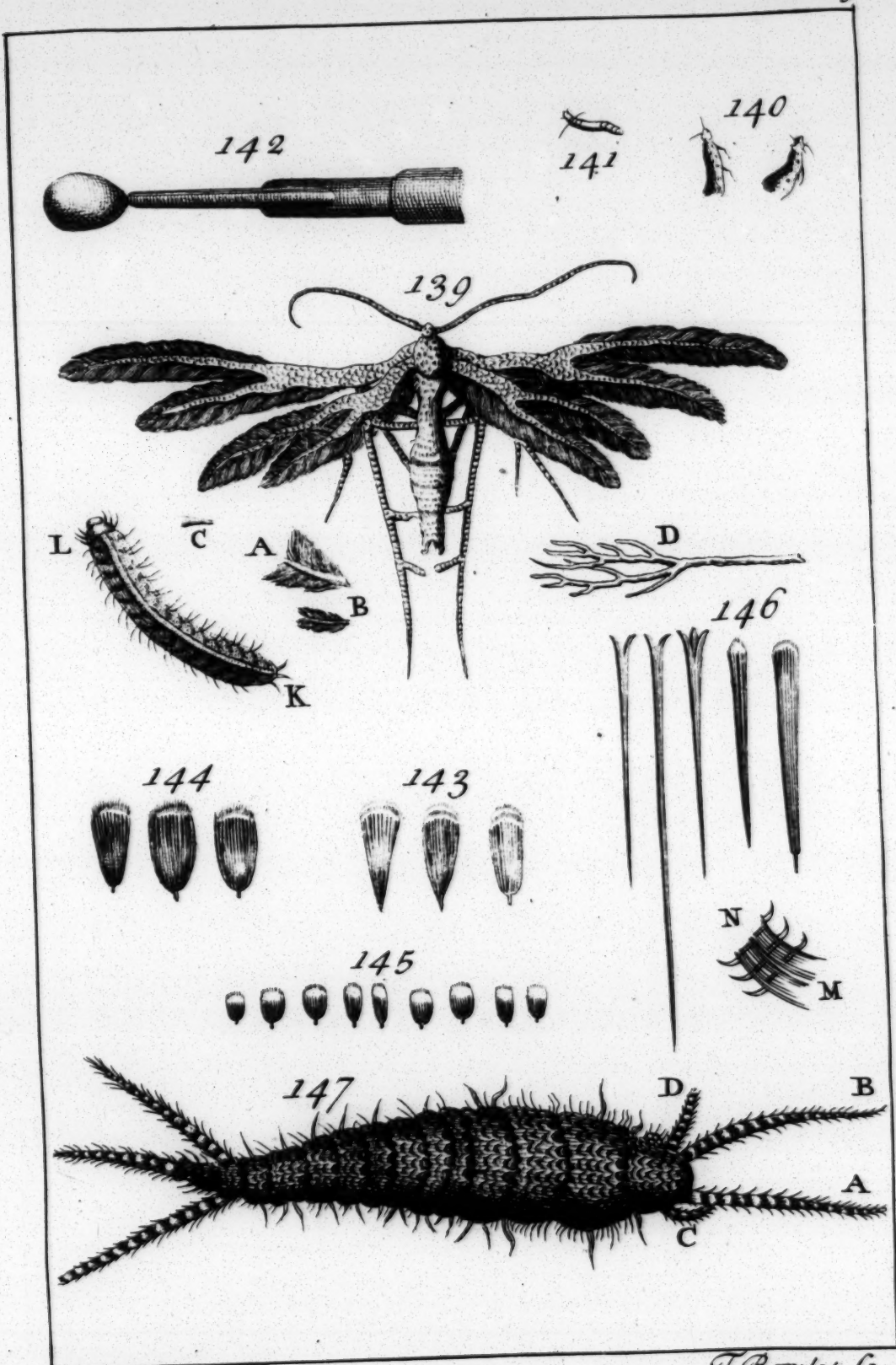
* *Leeuwen. Exp. & Contemp. Epist. 71.*

along the Walls; in the Fly-State they eat nothing, therefore are not mischievous, but soon copulate and lay Eggs, not larger than a Grain of Sand, in Shape like those of an Hen, each Female *sixty* or *seventy*, which by Means of a Tube at the End of her Tail, represented by Fig. 142. as it appears in the Microscope, she thrusts or insinuates into the little Wrinkles, Hollows, or Crevices of the Corn; where in about sixteen Days, they hatch, and then the Plague begins: For the minute Worms or Maggots immediately perforate the Grain where they are hatched upon, eat out the very Heart of it, and with their Webs cement other Grains thereto, which they likewise scoop out and devour, leaving nothing but Husks and Dust, and such a Quantity of their Dung, as shews them to be more voracious Insects than the *Weevil*, hereafter to be describ'd.

These *Worms* or *Maggots* may be kept all the Winter in Glas Tubes, that are stopped at each End with a Cork and Wax, having first a Bit of a very small Glas capillary Tube, put thro' the Cork to give them Air. In this Manner Mr. *Leeuwenboek* confin'd some of these *Moths* with a few Grains of Corn, and saw them lay their Eggs in the Crevices of the Corn; also in this Manner he observed all the above Particulars. Therefore as these *Glas Tubes* may be readily applied to the *Universal Microscope*, and are also very commodious to confine any Kind of Insect, in order to observe their Manner of Propagation, I apprehend it will not be improper to exhibit a Drawing of one of them in this Place, Fig. 25. A, B, C, D, represents a Glas Tube A D and B C, its Extremities stopped with Corks and Wax. E G and F H are two exceeding small Glas Tubes, cemented in the Corks, but so that the Air may have a free Passage quite thro' them. These Tubes are to be placed between the Object-Plate I, and Springs b, of the *Universal Microscope*, Fig. 1. several Dozens of them will be necessary to confine a few out of the great Variety of Insects that one Summer Season produces, therefore any Gentleman may be supplied with more or less of them as he pleases, at my Shop at the Sign of *Tycho Brahe's Head*, in *Fleet-Street*, LONDON, where I always keep them ready prepared.

These little *Moths* are cover'd all over with an infinite Number of little Feathers joined to their Wings, and other Parts of their Bodies by a Quill, as those of Birds are, but so extremely different in Shape, that scarce two of them can be found alike. Fig. 144. shews three of the larger Sort, somewhat blackish towards the Top, but transparent near the Stalk. Fig. 143. shews three others perfectly transparent, ten of the smaller Sort are exhibited at Fig. 145. but all of them of a different Shape. These Feathers which compose the Borders of the Wings, but especially those which grew upon that Part of the Wing which was near the Body of the Moth, were also of different Fashions, and much longer than the former. Five of this Sort are shewn at Fig. 146.

The





The Methods of destroying this Vermin is, when they forsake their Food, and ascend the Walls, or when they appear in the Moth State ; at both these Times they may be crushed to Death by clapping Sacks upon them : But they may still be more effectually destroyed by closing up all the Doors and Windows, and filling the Corn-Chambers with the Fumes of Brimstone *, by leaving it burning on a Pan of Charcoal, without giving it any Vent for 24 Hours : However, after that great Care must be taken to open them all again for some Hours, that the Fumes may be entirely gone before any Body enters.

N. B. The Fumes of the Sulphur are not hurtful to the Grain.

The *Nymph* of the *Cloaths Moth*, called by Mr. *Hook*, the silver colour'd *Book-Worm*, is a curious Object. It is a small silver colour'd shining Worm, and is often found scudding among *Books* and *Papers*. Fig. 147. represents this Worm as it appears in the Microscope, having a conical Body, divided into fourteen shelly Partitions, each of which are cover'd with a Multiplicity of thin transparent Scales, which from their several reflecting Surfaces, make the whole Animal appear of a perfect Pearl Colour: The small blunt Head of this Insect is furnished on either Side with a Cluster of Eyes, (but fewer in Number than those of other Insects) each of which was beset with a Row of small Bristles. It has two long Horns A B, strait and tapering towards the Top, curiously ringed and bristled, with a Girle of smaller Hairs at each Ring, and several larger Bristles here and there dispersed among them, also two shorter Horns or Feelers C D, knotted and fringed like the former, but without Bristles ; its hinder Part terminated in three Tails, resembling the two long Horns in every Particular. It had six Legs scaled and hair'd, which could not be represented in this Position. These little nimble Animals are best applied to the Microscope, upon a single Piece of Talc, or a thin Slip of Glas, pinched in the Nippers, having first stuck them thereto with a slight Touch of Turpentine, or a Drop of Gum Water.

C H A P. XX.

Of the Weevil, or Corn-Beetle.

THIS little *Insect* is somewhat bigger than a large Louse of the Scarab Kind. It does much Harm to many Sorts of Grain, by eating into them, and devouring all their Substance : As many People are unacquainted with the *Weevil*, I have exhibited a Picture of it, in Fig. 148. of the full Size it appears of to the naked Eye. It has two jointed Horns, which are represented as they appear when viewed through a Microscope, at

* *Leeuwen. Exp. & Contemp. Epist. 71. p. 246.*

E, H, G, Fig. 149. Its Trunk at E D B, and its Forceps or sharp Teeth D, with which it gnaws its Entrance into the Heart of the Grain, either for Food, or to deposite its Eggs. Between the Forceps at D, appears a Kind of Sucker, with which it licks up the Flower or Dust of the Grain.

If some of them are kept in Glass Tubes, prepared as before described, that the Air may have a free Passage into them, with a few Grains of Wheat, their Copulation may be discover'd, and also their Manner of Generation, which is thus performed. * The Female perforates a Grain of Wheat, and therein deposite a single oblong Egg or two at the most, and this she does to five or six Grains every Day, for several Days together; these Eggs, which are not above the Size of a Grain of Sand, in about seven Days produce an odd Sort of white Maggot, which wriggles its Body very much, but is scarce able to move from Place to Place, the Maggot turns into an Aurelia, which in about fourteen Days comes out a perfect *Weevil*.

C H A P. XXI.

Of the Flea.

THESE little Creatures are a surprizing Object, when examined by the Microscope; they are *Male* and *Female*, and undergo the same Changes as the Silk-worms do. They deposite their Eggs at the Roots of the Hair † of *Dogs*, *Cats*, and other Animals, and by a glutinous Matter stick them fast thereto; one of these Eggs is represented magnified in Fig. 150. and at 151. the same Egg broken by the Worm, Fig. 152. hatched therein. This Worm § contains the *Flea*, and is composed of several annular Divisions, thinly set with long Hairs, having at its Head two extremely minute Horns at A; these Worms feed upon the Juices of the Body whereunto they closely adhere. They are very nimble, but if disturbed, roll themselves suddenly into a round Figure, and continue motionless for some Time; after which they open themselves by Degrees, and crawl swiftly away. They endeavour to conceal themselves when their Change draws nigh, eat nothing, lie quiet, and appear dying, but if placed before the *Microscope*, will be found with the Web in their Mouths, weaving a Covering round them; the Inside of which is perfectly white, but its Outside as it were soil'd with Dirt. In this Bag they put on the *Chrysalis*, which is represented at Fig. 153. divested of its *Vermicular Skin*. About two or three Days before they break forth from this Confinement, their

* *Leeuw. Eip. of 6 Ang. to the Royal Society.*
Tom. IV. Epist. 76.

† *Phil. Transf. No. 249.*

§ *Arc. Nat.*

Colour darkens, and as soon as they issue from the Bag, are perfect *Fleas*, and able to leap away. A *microscopick* Picture of a perfect *Flea* is represented by Fig. 158.

It is all over adorn'd with a curiously polished Coat of Armour, or hard shelly Scales, neatly jointed and folded over each other, and beset with long Spikes, almost like Porcupines Quills: Its Neck bears some Resemblance to a Lobster's * Tail: Its Head is adorn'd on either Side with a beautiful quick and round black Eye; behind each of which appears a small Cavity, in which moves a thin Film, set with many small transparent Hairs, which may probably be its Ears †. From the fore Part of its Head, proceeds a Pair of little jointed hairy Horns, or Feelers A B. Between these and its two fore Legs C D, is situated its *Piercer* or *Sucker*, that includes a Pair of Darts, which after the *Piercer* has made its Entrance, are probably thrust farther into the Flesh, to make the Blood flow from the adjacent Parts, that it may be sucked up; and seems to occasion that round red Spot, with a Hole in the Center of it, which we commonly call a *Flea-bite*. This *Piercer*, its Sheath opening side ways, and the two Lancets within it, are very difficult to be seen, || unless the two fore Legs, between which they are usually folded in, and concealed from View, are cut off close to the Head; for a *Flea* rarely puts out its *Piercer*, except at the Time of feeding, but on the contrary keeps it closely folded inwards; one Way therefore of coming at it, is by cutting off the Head first, and then the fore Legs; since in the Agonies of Death, it may easily be managed and brought before the *Microscope*. But this requires a great deal of Patience and Dexterity. Therefore another more likely Way to succeed in this Experiment, is, when the *Flea* is just dead, to take hold of its Back with the Nippers m, of the Apparatus V, Fig. 2. and then apply it to the sixth Magnifier; and having a small sewing Needle ready fixed in a Handle, I have been able to press the Horns forward with the Point of the Needle, and its two fore Legs nearer to the Body; and this whilst I was looking thro' the *Microscope*; by which Means I could then exactly see where to place the Point of the Needle, so as to raise up the *Piercer* in the Situation D E, as expressed in Fig. 154. which represents a Part of the *Flea's* Head; and at the same Time I have open'd the *Piercer*, and separated its two Lancets, and this without cutting off any Part of the *Flea*, Fig. 154. A B C are the two Horns, and D E are the two Sides of the *Piercer*, which are partly hollow, that they may the better include the Lancet, or Dart, which in this Figure appears to be but one, but if carefully separated, will be found to consist of two Parts, as in the next Figure 155; whereof G K and G I represent as before the two Parts of the *Piercer* be-

* *Pow. Mic. Obs.* p. 2.
Ph. Transf. No. 249.

† *Hook's Mic.* p. 210.

|| *Arc. Nat. Tom.* IV. p. 332.

set with several Hairs, and G H shews the two Darts, but not separated. At Fig. 156. they may be seen asunder, whereof L O, L N, are the two hairy Parts of the Piercer before spoken of, and L M, O L P the Darts, in L M may be seen the Cavity, which includes or receives the other Dart L P, when they are shut up between the *Fleas* fore Legs, all the four make but one Proboscis.

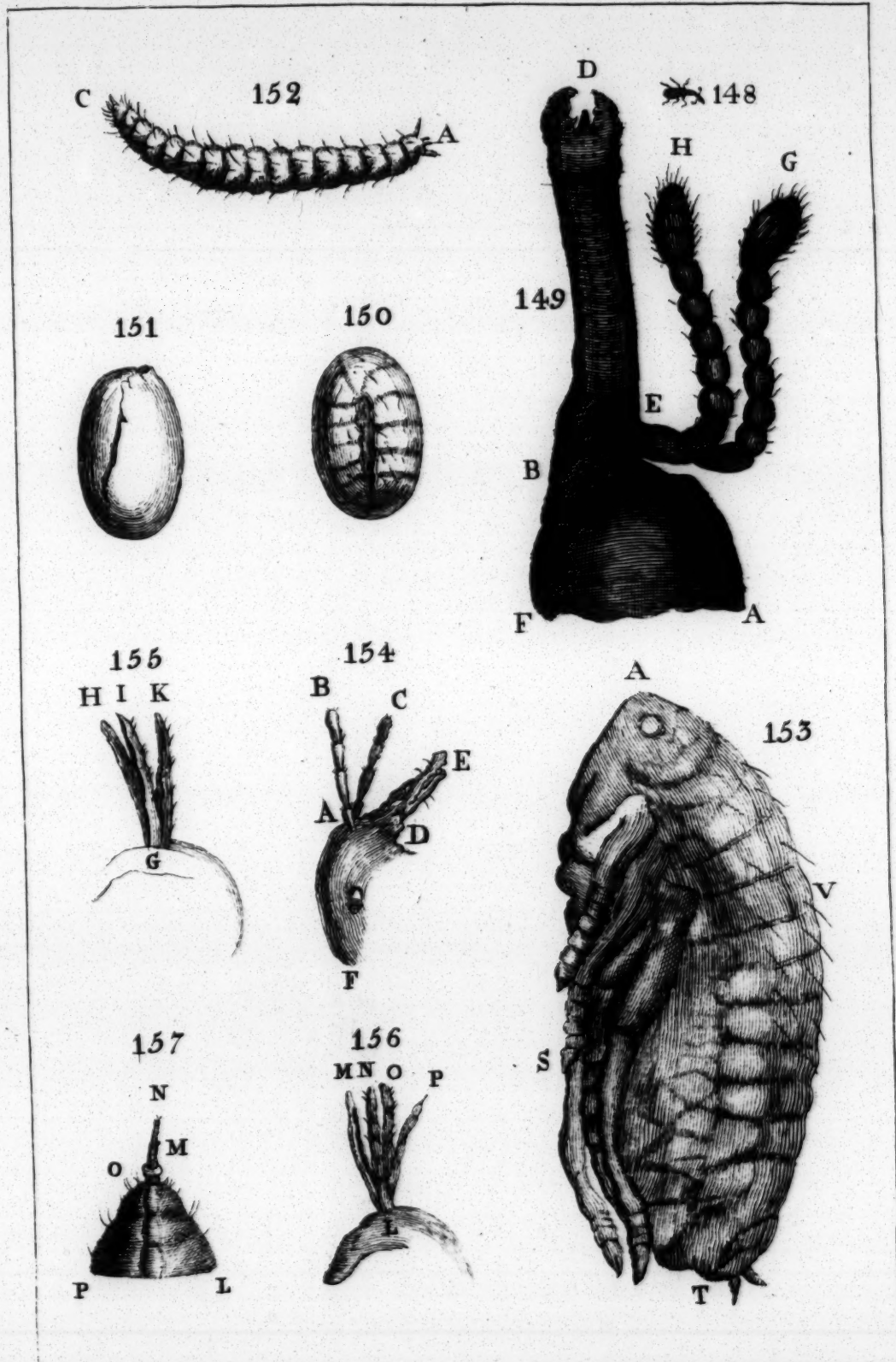
Besides these two Legs before spoken of, which adhere to the Head of this little Creature, it has four others, which are join'd to its Breast; these six Legs the *Flea* clutches up altogether; and when he leaps, springs them all out at the same Instant, and thereby exerts his whole Strength at once, which carries him to a surprizing Distance, above 100 times its own Length. Its Legs have several hairy Joints, which terminate in long hooked Claws; as in Fig. 158.

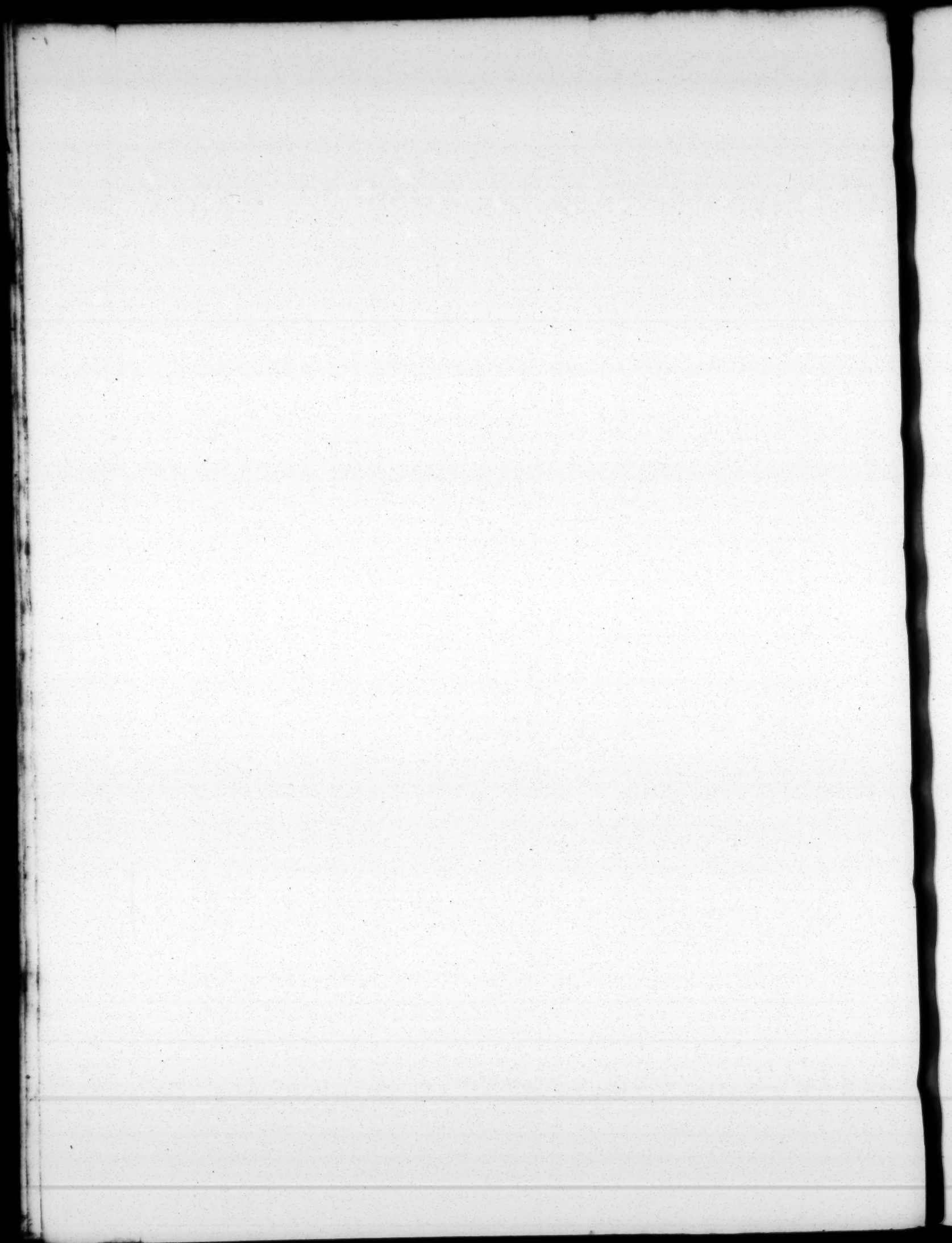
If the Eggs of *Fleas* be kept constantly warm in one's Bosom (it has been observed that) in the Midst of Summer, they hatch in four Days; then feed the Maggots with dead Flies, which they greedily suck. In eleven Days they come to the full Perfection of the Reptile State, when the Maggot spins its Bag, and in four Days more changes into a *Chrysalis*; after lying in which Condition nine Days, it becomes a perfect *Flea*. It is then immediately capable of Coition, and in three or four Days lays Eggs; so that in * 28 Days, a *Flea* may come from its Egg, and propagate its Kind; and their vast Increase will not seem so great a Wonder if we consider, that from *March* to *December* there may be seven or eight Generations of them; after having laid their Eggs they soon die, as all Creatures do that undergo such like Changes.

If you keep *Fleas* in such a Glass Tube, as is before described, so as to admit fresh Air, their several Actions may be observed, and particularly their Way of Coupling, which is performed Tail to Tail. The Female (which is much the larger) standing over the Male: They will also be seen to lay their Eggs, not all at once, but ten or twelve in a Day for several Days successively; which Eggs hatch in the same Order.

A Dissection of the *Flea* may be effected in Water, the † Stomach and Bowels, with their peristaltick Motion, may plainly be distinguished, and also the Testes and Penis, together with Veins and Arteries, minute beyond Conception. Mr. *Leeuwenhoek* affirms, that he has likewise discover'd innumerable *Animalcules*, shaped like Serpents, in the Semen Masculinum of a *Flea*.

* *Arc. Nat. Tom. IV. p. 325.* † *Ibid. p. 335.*





C H A P. XXII.

Of the Louse.

THE Transparency of its Skin enables us by the Help of the *Microscope*, to discover the Motion of the Muscles, * (which unite in an oblong dark Spot in the Middle of its Breast) as the *Louse* moves its Legs; and also in the Head, when the Horns are moved, and in the several Articulations of its Legs. The peristaltick Motion of the Intestines is really surprising, which is continued from the Stomach thro' the Guts to the Anus. The various Ramifications of the Veins and Arteries, which are white, and a regular Pulse may be also discern'd. From its Head proceeds two hairy Horns B B, Fig. 159. with four Joints. Its two black Eyes are shewn at C C, fenced round with several small Hairs; it has six Legs, cover'd with a very transparent Shell, and jointed exactly like a Crab's or Lobster's Claws; each Leg hath five Joints with several small Hairs interspers'd about them; at the End of each is two sharp hooked Claws, as may be seen in the Figure, unequal in Length and Size; one of which resembles that of an Eagle, but the other of the same Foot † stands strait out, and is very small; between these two is a raised Part or Knob, most exquisitely contrived for performing those Motions of walking and climbing up the Hairs of the Head; for when it walks, by having the lesser Claw G set so much short of the bigger H, that the former does not touch, and by Means of the small Joints in the latter, it is able to bend it round, and so with both Claws to grasp and hold fast the Hairs ‖. From its Snout at the Hole D, when the *Louse* is going to feed, it pushes out a pointed Part, which is represented at Fig. 157. whereof L O P is the Snout Part of the Louse's Head. At O is the Nipple, from whence the Sheath, or Case M, and from within this also, the Piercer § or Sucker N is pushed out; at N, its Point is somewhat cleft. These are thrust into the Skin to draw out the Blood and Humours it feeds on; for Mr. *Hook* placed a *Louse* upon the Back of his Hand that had been fasting two or three Days, which immediately thrust its Sucker into the Skin, and he could plainly see a small Current of Blood come directly from its Snout in a fine Stream to the fore Part of the Head, and then to fall into a roundish Cavity; it passes again in a like Stream to another circular Receptacle in the Middle of the Head at A, from thence through a smaller Vessel to the Breast; and then to a Gut that reaches to the hinder Part of the Body, where in a Curve it turns a

* *Philos. Transf.* No. 284. † *Ibid.* No. 94. ‖ *Hook's Microsc.* p. 212. § *Lecturæ an.* Exp. & Con. p. 354.

little upwards. In the Breast and Gut the Blood without Intermiffion is moved with great Force, and in the Gut with fuch a ftrong Propulfion downwards, and fuch a Contraction of the Gut as is furprifing. In the upper Part of the crooked afcending Gut the propelled Blood ftands ftill, and feems to undergo a Separation; * part of it becoming clear and waterifh, while certain little black Particles pafs downwards to the Anus. The Thorax is cased with a transparent horny Subftance, through which the Blood was variously diftributed; and at I, appeared a pretty big white Subftance; many very fmall milk-white † Veffels were difcernable between its Legs, out of which on either Side were many minute Branchings. The Belly is covered with a thin transparent Skin; at the upper End of this its Stomach K K is placed, and the white Spot L; at the Extremity of the Tail are two femicircular Parts covered all over with Hair.

Place a *Loufe* on its Back and two darkifh bloody Spots will appear; the larger in the Middle of the Body, and the leffer towards the Tail. In the larger Spot a white Film ‡ or Bladder contracts, and dilates upwards and downwards from the Head towards the Tail; the Pulse of which is followed by a Pulse of the dark bloody Spot, in or over which the white Bladder feems to lie. This Motion of Syftole and Diaftole is feen beft when the Loufe is grown weak; the white pulfing Bladder feems to be the Heart, for on pricking it the Loufe infantly dies. The lower darkifh Spot is thought to be the Excrement in the Guts.

The Males have Stings ¶ in their Tails, the Females none: The Females lay Eggs or Nits, from whence Lice are produced perfect in all their Members, and undergo no farther Change.

Mr. *Leeuwenhoek* obferved that in fix Days one of them had laid 50 Eggs, and diffecting it, he faw as many more in the Ovary; concluding from thence that it would have laid 100 Eggs in 12 Days. Thefe Eggs hatch'd in fix Days, would probably produce 50 Males and as many Females; and thefe Females coming to their full Growth in 18 Days, might in 12 Days more probably lay 100 Eggs alfo, which Eggs in fix Days farther, the Time required to hatch them, might produce a young Brood of 5000; fo that in eight Weeks a *Loufe* may fee 5000 ** of its own Descendants.

Upon the oblong Slip of Glafs R, Fig. 2. a *Loufe* may be eafily difsected in a fmall Drop of Water and applied to the *Microscope*; thus five or fix Eggs ready to be laid may be found in the Ovary of a Female, with many other of a lefs Size. In the Male the Penis is remarkable, and alfo the Teftes, whereof it has a double Pair. The Females appear very white if fafting, and even when fed are lefs red than the Males.

* *Phi. Tran.* No. 102. † *Hook's Micro.* p. 213. ‡ *Porw. Mi. Ob.* p. 9. ¶ *Arc. Nat. Tom.* II. p. 77. § *Ibid.* p. 77. ** *Ar. Nat Tom.* I. p. 78.

The Vermin adhering to and feeding on the Bodies of different Animals, are commonly called Lice.

Insects are infected with Vermin that feed * on and torment them ; several Beetles have Lice on them.

The Earwig is troubled with minute Insects, which stick like Lice on the several Parts of the Body, especially under the setting on of its Head. They are white like Mites, but smaller ; are round back'd, flat bellied, long legged, especially the two foremost, the same has not been observed on any other Animal.

Snails of all Kinds have Insects feeding on them. Small red Lice are frequently to be seen about the Legs of Spiders.

White Lice are commonly found on Humble-Bees, on Ants, on Fishes, &c. and probably very few Creatures are free from them.

The Polipe also is not exempt from Vermin of this Sort.

There is another Sort of Louse found about unclean People, called a Crab-louse.

Seignior *Redi* at the End of his Treatise *de Generatione Insectorum*, hath obliged us with Microscopick Drawings of several Sorts of Lice, that feed upon the Bodies of different Animals, to which I refer the Reader.

In the Hawk and Turkey Hen he observed three Sorts, four in the Wild Duck, in the Wild Goose, Swan, Kestrel and Plover two ; yet there are several Sorts of Birds, which have either the same Sort of *Lice*, or some nearly like them. The Kestrel hath a sort of *Lice* differing only in Colour from those of the Raven ; and the Raven others, like those found upon the Egret : On the Wood-pecker and Chafinch are some resembling those of the Starling ; on the large Wild Duck are some much like those of the Wild Goose. It is also observable, that the Bigness of each Bird's *Lice* bears no adequate Proportion to the Bigness of the Birds they are found upon ; but that on the largest Birds both large and small *Lice* of different Kinds may be found ; for on the Black-bird hath been seen some as large as those on the Swan.

There is also a little Animal in Shape and Colour like a Louse, commonly found among the Leaves and Covers of Books, and in rotten Wood ; it has a swift Motion and runs by Starts ; it is called a *Wood-louse* † or *Wood-mite*. If this Animal be stuck upon the Point of a very fine sewing Needle with a little Turpentine, it will be found a very curious Object ; its whole Body being cased in annulary Circles, full of Silver Hairs, especially towards the Tail, with six Legs, that terminate in two Talons ; it hath two Horns, but pointing backwards ; its Eyes are of a golden Colour, and pushed out or drawn in at Pleasure ; it hath also two Pointers before like a Pair of Pincers.

* *Phi. Tran. N^o. 288.*

† *Pow. Mi. Ob. p. 10.*

C H A P. XXIII.

Of Mites.

S E C T. I.

THEY are crustaceous Animals, having a small Head in proportion to their Bodies, a sharp Snout and Mouth like that of a Mole, * when open it appears red; they have two little Eyes, some have six Legs, others eight, each of which terminate in two hooked Claws: The Divisions of the Head, Neck and Body are easily discernable by the Microscope; the hinder Part of its Body is plump, and of an oval Form, with a few exceeding small Hairs issuing therefrom, and from other Parts of its Body also. The Female lays Eggs, the young ones issue forth with all their Members perfect, though extremely minute; they cast their Skins several Times before they attain their full Growth.

Fig. 160. represents one of the *Mites* in *Cheese*; its Head is seen at A, and exactly answers the Description before given. One of a Mite's Eggs is seen at Fig. 165.

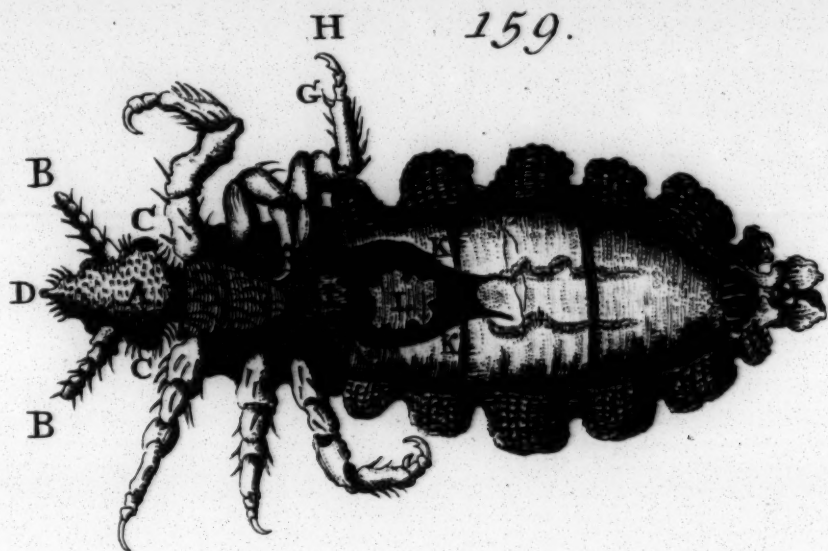
They may be kept alive many Months between two concave Glasses, and applied at Pleasure to the Microscope; by often looking at them they may frequently be seen *in coitu*, † conjoin'd Tail to Tail, for though the Penis of the Male be in the Middle of the Belly, it turns backwards like the Rhinoceros. The Coitus is performed with an incredible swift Motion. In warm Weather their Eggs hatch in 12 or 14 Days; but in Winter-time and cold Weather not under several Weeks: The young ones may be frequently seen near a Day struggling to get clear of their Egg-shell.

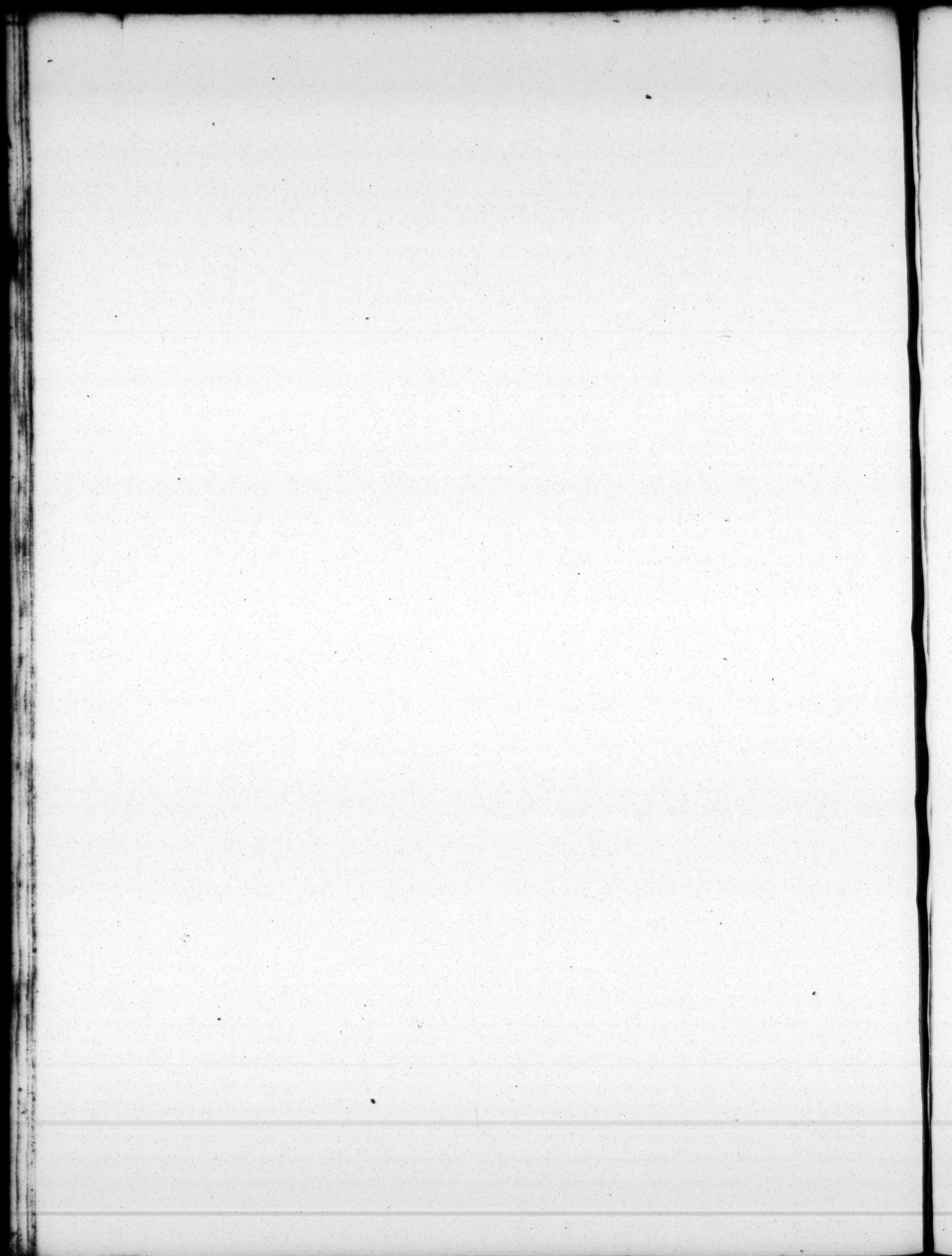
S E C T. II.

Of the wandering Mite.

THESE Creatures appear to the naked Eye to be a kind of *black Mite*, though much nimbler and stronger than the *Cheese Mites*, but on viewing them in the *Microscope*, they will be found to be a very fine crustaceous Insect, like Fig. 161. with a protuberant oval Shell indented with several small Pits, covered all over with white Bristles, they have eight Legs, each of them furnished with a sharp Claw at the End. The

* *Pow. Mi. Ob. p. 16.* † *Arc. Nat. Tom. IV. p. 360.*





Thorax was cover'd by two Shells, its Snout taper with a knobbed Ridge* running along the Middle of it; just over each of its Eyes arose two very long and strong Bristles, its Eyes black and smooth like those of bigger Insects. These Mites are to be met with on almost any Substance where they can get Food.

Another Sort of *Mite* as delineated by Dr. *Hook*, is represented in Fig. 162, cover'd with a curiously polished Shell, which reflected the Light from all Sides.

These Creatures are very much diversified in Shape and Colour, and in several other Circumstances, according to the Nature of the Substance out of which they seem to be fed, † being in one longer, in another rounder, in some more hairy, in others smoother, in this nimble, in that slow, here pale and whiter, there browner, blacker, or more transparent. They are to be met with almost on all Kinds of Substances, that are mouldy or putrifying, in *Oatmeal*, and in *Malt-Dust*; there are Mites bred among *Figs*, ‖ in *Hay*, and in the Powder that falls off dried Roots ‡. They are voracious Animals, and devour not only Cheese, but also all Sorts of dried Flesh, Fish, Fruits, and Grain, and almost every Thing besides that has a certain Degree of Moisture, without being over-wet. Fig. 164. represents a small Hair of a *Mite* as delineated by Mr. *Leeuwenhoek*, which a certain Gentleman compared to an *Indian* or *Japan Cane*, †† with several Joints, and said it appeared to him through the *Microscope* as if sharp Twigs were sprouting out of each Joint. And Fig. 163, represents another Hair or Bristle of a *Mite* magnified, which was spicated, or bearded like the Ear on the Seed-beard ** of some Grass. Every Bristle on its Body and Legs had the same Formation; yet all Mites are not so; for of seven or eight which were inclosed together, but one of them was found whose Bristles were all of this Make, in the rest the Horns only were spicated.

Their Mouths open horizontally to the Right and Left, like that of a Wasp; several of them being shut up together without Food for some Days, some were found dead, and the Survivors preying on them; by which Means their manner of feeding †† was observed, which is very remarkable; for they thrust one Mandible forwards, and draw the other backwards at the same Time, and thus they do alternately; so that they seem to grind their Food. After feeding they munch or chew the Cud.

Mr. *Leeuwenhoek* hath observed that *Mites* in Cheese turn into *Aurelias*, and from thence to *Flies*; when they turn into *Aurelias* ‖ they are inclosed in a thin transparent Membrane, which in some measure screens them from the Insults of the Maggots that swarm in Cheeses. He also observed some

* *Hook's Mi. p. 206.* † *Ibid. p. 214.* ‖ *Pb. Tran. No. 333.* ‡ *Power's Mi. Ob. p. 18.*
 ** *Ibid. No. 284.* †† *Ibid. No. 333.* ‡‡ *Ibid. No. 284.* ‖ *Ibid. No. 262.*

of the Flies produced from these Cheese-Worms, that he kept in a Glass-Tube in which he had put Cheese for them to feed upon, had coupled; and soon after laid Eggs of an oblong Figure, and then died: From these Eggs came young Worms, which also fed on the Cheese, and when he judged them to be at their full Growth, and the Weather began to be cold, he took six of the biggest, and carried them about him; and a few Days after he observed that four of them were changed into *Aurelias*, that two Worms were dead, and two *Flies* skipping about the Glass; he repeated the same Thing in *January*, and with the like Success; when he kept them in the Cold, little or no Sign of Life or Motion appeared; but as soon as he put them into his Pocket, they were as brisk as in Summer. Upon opening an *Aurelia* that had never produced a Fly, a dead one was found within it, which had been making its Efforts to get out, but was not strong enough to effect it.

These Vermin creep into the Cabinets of the Curious, and destroy their choice Collections of Insects: But to prevent this, keep in your Drawers, &c. a continual Supply of Camphire, whose hot and dry Effluvia will penetrate, shrivel up, and destroy the tender Bodies of these little mischievous Plunderers.

S E C T. III.

Of a Crab-like Insect.

THIS Insect is about the Bigness of a large *Mite*, and of a very curious Form, as delineated in Fig. 166, it had ten Legs, eight of which *aaaa* terminated in very sharp but double hooked Claws, being those it walked upon, which were shaped much like those of a Crab: the two other Claws *AA*, that were the foremost of all the ten, seemed to branch out from its Head, and were exactly formed like Crabs, or Lobsters Claws, as are expressed in the Figure, whose Ends terminated in a Pair of Pincers, (with which I have often seen him stroke those other Claws *EE*) which grew out of his Snout; in walking the Creature elevated the former above its Head and Body; its Eyes were situated about *dd*, its Head was covered with a kind of scaly * Shell at *F*, its Thorax *GG* with two smooth Scales, and its Back with eight knobbed ones *HH*. These Insects are frequently to be met with amongst Books and Papers that come from *China*, when first unpacked.

* *Hook's Micr. p. 208.*

C H A P. XXIV.

Of the Semen Masculinum.

S*pontaneous Generation*, is a Doctrine so generally exploded, that a Disproof of it is altogether needless in this Place, it being put beyond all Dispute that all *Animals* and *Vegetables* owe their Production to parent *Animals* and *Vegetables*; and that *Animals* are from *Animalcula*.* These *Animalcula* being originally in the *Semen* of the *Male*, and not in the *Female*; therefore can never come forward or be formed into *Animals* of their respective Kinds, without the *Ova* in the *Female* †.

By the Assistance of a good Microscope, Myriads of *Animalcules* may be discovered in the *Semen Masculinum* of *Animals*, alive and vigorous; though so exceedingly minute, that it has been computed 3,000,000,000 of them are not equal to a Grain ‡ of Sand.

The general Appearance of the *Animalcules* in the *Semen Masculinum* of different Creatures is very much the same, that is, their Bodies all seem to be of an oval Form, with long tapering slender Tails issuing therefrom, somewhat resembling Tadpoles: Though their Tails in Proportion to their Bodies are much longer than those of Tadpoles. And the *Animalcules* in the *Semen* of *Fishes* have Tails still longer and slenderer than either, inso-much that the Extremity of them is rarely to be discerned. Their general Appearance as above described is shewn Fig. 187.

Mr. *Leeuwenhoek*, upon viewing the Milt of a *Cod Fish* || with a *Microscope*, observed therein such prodigious Numbers of living *Animalcula*, with long Tails incessantly moving to and fro, (he observed the same Thing in the Milts of *Pikes* or *Jacks*) that according to his Computation 10,000 of them might be contained in the Quantity of one Grain of Sand §. Whence he argues, that there are more living *Animalcula* in the Milt of one *Cod-fish*, than there are *People* alive upon the Face of the whole *Earth*, at one and the same Time. He computes one hundred Grains of Sand to make the Diameter of an Inch, then a cubic Inch will contain a Million of such Sands. And as he found the Milt of the *Cod-fish* to contain 15 Inches, it must contain 15 Millions of Quantities as big as a Grain of Sand; and if each of these Quantities contain 10,000 *Animalcules*, the whole must contain one hundred and fifty thousand Millions. Then to calculate the Number of *People*, he reckons a great Circle to contain 5,400 *Dutch square Miles*: Whence he calculates the *Earth's Surface* to contain 9,276,218 such square Miles: And supposing one Third of the whole or 3,092,072 Miles

* *Phi. Tr.* No. 192. † *Vide Harris's Lex. Tech.* under the Word *Generation*. ‡ *Vide Keil. Anat.* p. 116. || *Ph. Collections*, No. I. p. 3. § *Arc. Nat.* Tom. I. Par II. p. 9.

to be dry Land ; and of this $\frac{2}{3}$ or 2,061,382 Miles to be inhabited. And supposes farther, that *Holland* and *West-Frizeland* are 22 Miles long, and 7 broad, which make 154 square Miles : The habitable Part of the World is then 13,385 times the Bigness of those Places.

If the *People* in these two *Provinces* are suppos'd a Million, and that all the other Parts of the World are as populous as these, which is improbable, there would be 13,385 Millions of People on the Face of the whole Earth : But the Milt of this Fish contain'd 150,000 Millions of *Animalcules*, which is 10 times more than the Number of Mankind.

The *Seminal Vessels* of a *Cock** being opened, and a small Drop of the *Semen* squeezed out, and apply'd to the *Microscope*, great Numbers of Animals were seen swimming therein in Legions, and crossing one another like Clouds in a stormy Day, as brisk as if the *Cock* was but newly dead, † altho' it was killed the Day before ; they appear as at Fig. 168. if viewed with due Attention, and with the greatest Magnifiers, otherwise only in the Form of Eels.

Mr. *Leeuwenhoek*, in the Spring-time, when the *Frogs* engender, open'd the Testicles of the Male, ‖ and on applying some of the *seminal* Matter to the *Microscope*, Multitudes of *Animalcules* appear'd therein, about $\frac{1}{1000}$ th Part of the Thickness of a human Hair ; and there seem'd to be ten thousand of them at least to each one of the Female *Ova*, their Form is as represented in Fig. 169.

Mr. *Leeuwenhoek*'s Method of computing the Size of *Animalcules* was this, he placed an Hair § of his Head near them, which Hair appear'd an Inch in Breadth ; and being satisfied that 60 of these *Animalcules* could lie within that Diameter ; whence their Bodies being spherical, 216,000 of them are but equal to a Globe, whose Diameter is no more than the Breadth of such an Hair. Another Method of his also follows.

He first suppos'd a Drop of Water equal to a Pea ; then took a little Quantity of Water, of a round Figure, as big as a Millet Grain ; and reckon'd this to be $\frac{1}{81}$ of a Pea ; ‡ for when the Axis of a Millet Seed makes 1, that of a Pea will make $4\frac{1}{2}$, whence it follows, that the Seed of a Millet is at least the $\frac{1}{9}$ of a Pea ; this small Quantity of Water he put into a very slender Glass Tube, dividing by this Means that little Water into 25 or 30 Parts, and found more than 100 *Animalcula* in the $\frac{1}{30}$ Part of Water, equalling the Bigness of a Millet Seed. Whence it appears, that if 1000 are to be seen in the $\frac{1}{30}$ Part of a Millet Seed, there may be seen 30,000 in one such whole Seed ; and consequently in a Drop of Water 91 times bigger, there may be seen 2,730,000. Besides he compared the Water to the Bulk of a Grain of Sand ; that if the Axis of a Grain of Sand be 1, that

* *Phil. Transf.* No. 279. † *Arc. Nat. Tom. II. Part II. p. 369.* ‖ *Arc. Nat. Tom. I. Part I. p. 51.* § *Phil. Transf.* No. 279. ‡ *Ibid.* No. 131.

of a Drop of Water is at least 10, consequently a Drop 1000 times bigger than that Grain of Sand, and therefore there are 1,000,000 of Animalcula in one Drop of Water, at the Rate of 1000 little Animals in that Quantity of Water.

* In the same Manner he also computed that 4,096,000 Eggs were in the Roe of a Crab. Each of which received its Nourishment by a String from the Crab's Body.

To view the *Animalcules* in the Milt or soft Roes of Fishes, squeeze out a little of it, and putting the Quantity of a Pin's Head upon the Glass R, dilute it with River or Rain-Water, till they have sufficient Room to swim freely about, and shew themselves to Advantage.

N. B. The Eggs † in the Roe and Animalcules in the Milt of Fishes of one Year old, are as large as in those of the same Species of twenty Years old.

Some of the feminal Matter taken from the Testicles of a Dog, ‖abounded with Animalcules in Form of Fig. 170. and some of them remain'd alive after having been kept seven § Days in a Glass Tube.

The Testicles of a Hare, altho' four Days ‡ dead, were found to be exceeding full of Animalcules, like those in Dogs, swimming in a clear Liquor, but without Motion.

A Female Rabbit being killed immediately after the Coitus, and the Uterus opened, innumerable Quantities of *Animalcules* were found in a small Drop taken from the Mouth of the Fallopian Tube, where it opens into the Matrix; but none were discern'd in the Uterus itself, or farther along the Tube; they had long Tails, and mostly ** six transparent Globules appear'd on the Body of each, as in Fig. 171. A; tho' some had only one Globule at the End of the Body, and another in the Tail, as Fig. 171. B.

A Buck being killed in Rutting-Time, the Vasa Deferentia were found turgid, and full of a milky Fluid, a Drop of which diluted with a Drop of warm Water, just enough to change its Colour, and then applied before the Microscope, appear'd full of *Animalcules* moving very briskly ‖‖.

A Drop of the seminal Matter taken from the Testicles of a Ram, flowed with *Animalcules* in as great Numbers as that of other Creatures; but with this Difference, that they swam in Drove together the same Way, and seem'd to follow their Leader §§ as Sheep do. Mr. Leeuwenhoek found so much Pleasure in this Observation, that he called in some Neighbours to share it with him.

This ingenious Enquirer after Nature, opened the Uterus of an Ewe, about seventeen Days after she had been coupled with a Ram; and in one

* Arc. Nat. Tom. I. Part II. p. 339. † Ibid. Tom. III. p. 188. ‖ Ibid. Tom. I. Part II. p. 160. § Ibid. p. 150, and 49. ‡ Ibid. Tom. I. Part II. p. 160. ** Ibid. Tom. I. Part II. p. 168. ‖‖ Phil. Transf. No. 284. §§ Leeuwenh. Epist. Phy. p. 388.

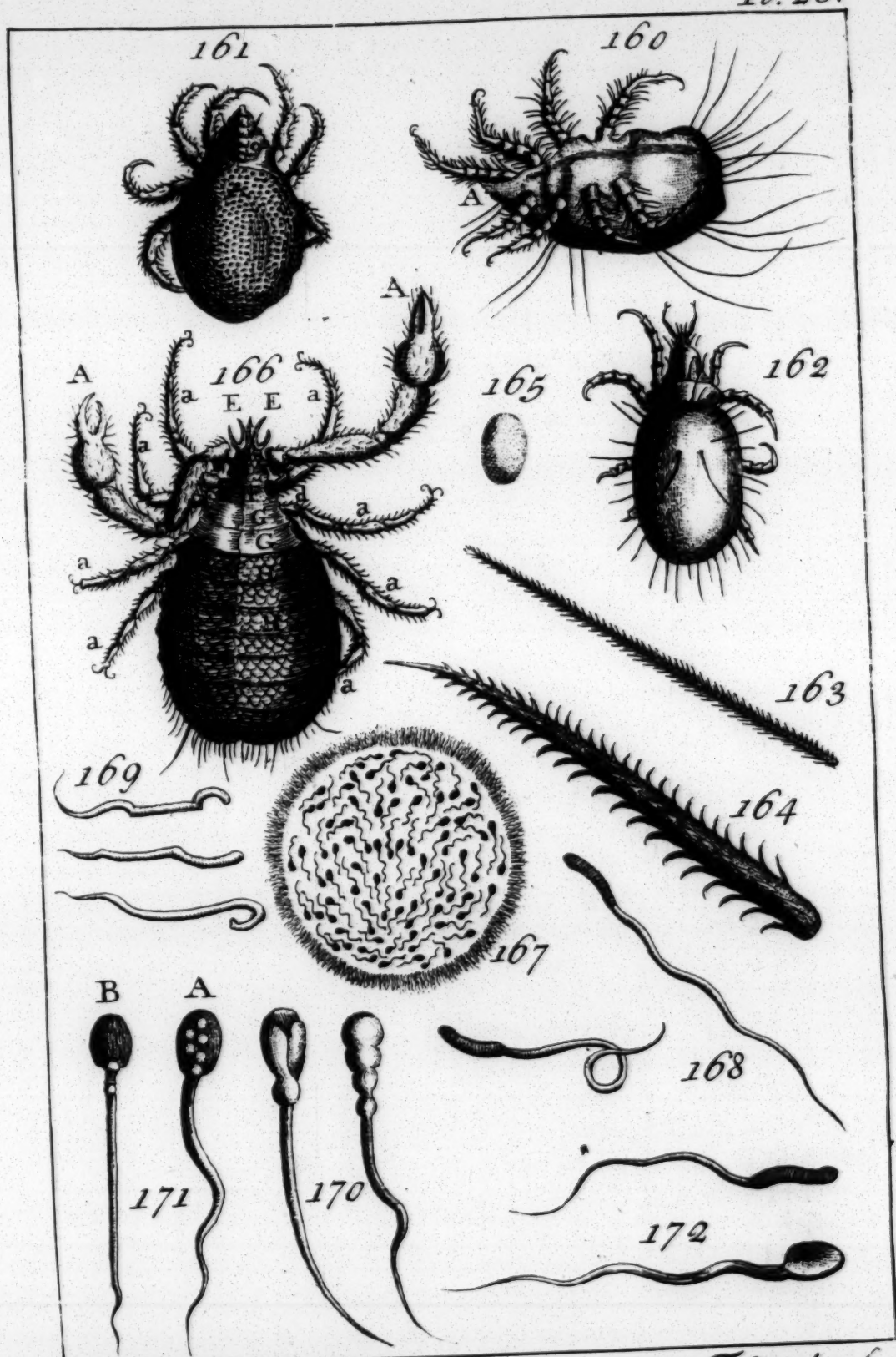
of the *Cornea* observed a little reddish fleshy Substance, wherein no Shape could be distinguished, which he extended very gently out of the Round in which it lay, and could plainly perceive the Formation of all the *Vertebrae*, with the *Blood-Vessels* and *Ramifications* passing over them, and could see the *spinal Marrow* in two Places *, and distinguished not only the *Head*, but also the *Mouth*, *Brain*, and *Eyes*, the Bigness of two Grains of Sand, and clear as Crystal; he likewise saw the *Ribs* and *Intestines*, tho' the whole Creature was no larger than the eighth Part of a Pea. After which he open'd the *Uterus* of another *Ewe*, † three Days from the *Coitus*, and searching the Liquor coming therefrom with a magnifying Glass, observed a little Particle the Size of a Grain of Sand; and examined it with a very good *Microscope*, and with great Pleasure found it to be an exceeding minute *Lamb*, lying round in its Integuments, and could plainly discern its Mouth and Eyes.

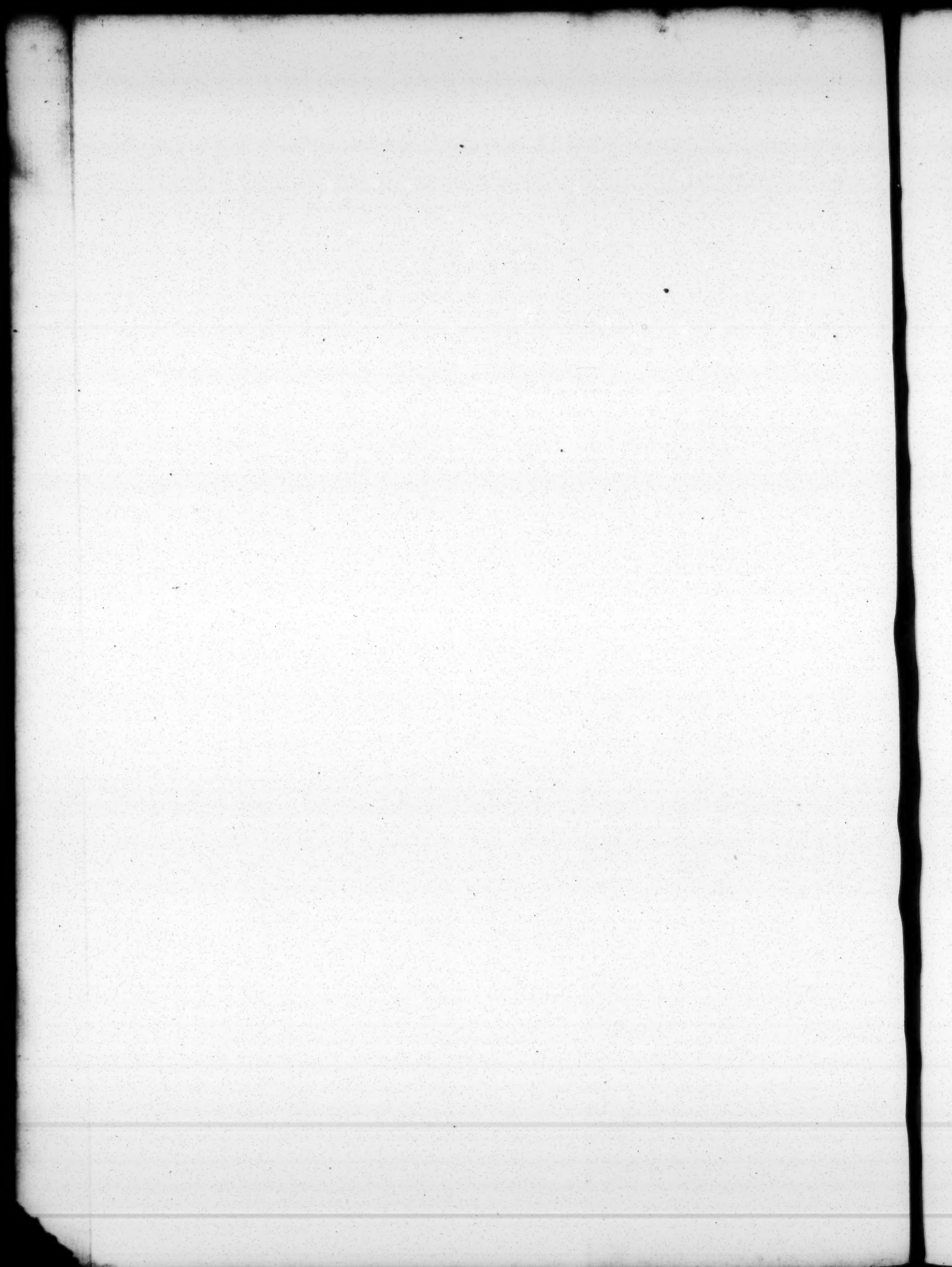
The *human Semen* has also been viewed by the *Microscope*, and found to be as plentifully stocked with *Animalcules*, as that of other Animals: Mr. *Leeuwenhoek* has seen more than 10,000 living Creatures moving in a Quantity of the fluid Part thereof, no bigger than a Grain of Sand: And in the thicker Parts, they were so thronged together, that they could not move for one another; their Size was smaller than the red Globules of the Blood, and even less than a millionth Part of a Grain of || Sand, their Bodies roundish and flat before, as in Fig. 172. but ending sharp behind. Their Tails are exceedingly transparent, and five times longer, and slenderer than their Bodies. They move by the Agitations of their Tails in various Bindings, after the Manner that Eels swim.

The § *Animalcules* in the *Semen Masculinum* of all Creatures differ but little in Shape or Bigness, for which Reason it follows, that the *Animalcules* may be discover'd in the *Semen* of the smallest *Birds*, *Quadrupeds*, and *Fishes*; nay, and even in Insects to. For Mr. *Leeuwenhoek* affirms, that he found in the white Matter he had sometimes squeezed from the hinder Parts of *Male* ‡ *Spiders*, a prodigious Number of *Animalcules*. He found them also in the *Semen* of the (a) *Dormouse*, in (b) *Oysters*, in (c) *Silkworms*, in the (d) *Labella minima*, or *small Dragon Fly*, the common (e) *Fly*, in the *Male* (f) *Flea*, in (g) *Gnats*, and many other Insects.

It is observable that amongst the many Species of *Animalcules* found in Waters, and other Infusions, there are none like those in *Semine*; but that these last, in all Sorts of Creatures, have a general Likeness to each other, and

* *Arc. Nat. Tom. I. Part II. p. 164.* † *Ibid. p. 173.* || *Arc. Nat. Tom. II. Part II. p. 61, 96, 286.* § *Ibid. Tom. IV. p. 30.* ‡ *Phil. Transf. No. 279.* (a) *Arc. Nat. Tom. I. Part II. p. 27.* (b) *Ibid. Tom. II. Part I. p. 144.* (c) *Ibid. Part II. p. 442.* (d) *Ibid. Tom. IV. p. 19.* (e) *Ibid.* (f) *Ibid. p. 20.* (g) *Ibid. p. 22.* (h) *Ibid. p. 294.*





appear in continual Motion without any Intermission, if the Fluid be but sufficient for them to swim in.

It is farther observable, that no *Animalcules* can be found in the *Blood*, *Spittle*, *Urine*, *Gall*, *Chyle*, or any other of the *Humours*, except the *Semen* only.

C H A P. XXV.

Of the Oyster.

MANY little round living *Animalcules* have been found in the clear Liquor of an Oyster, * supposed to be the *Animalcules* in the *Roe* or *Semen*.

Mr. *Leeuwenhoek* open'd an Oyster on the 4th of *August*, (which is the Time that Oysters are suppos'd to breed) and took out of it a prodigious Number of minute Oysters, all alive and swimming briskly in the Liquor, by the Means of exceeding small Organs, extending a little Way beyond their Shells, which he calls their Beards; in these he could distinguish the joining of the Shells, and perceived some that were dead, with their Shells gaping, and as like large Oysters in Form as one Egg is like another.

Upon opening a Female Oyster, incredible Multitudes of minute Oysters, cover'd with little Shells, perfectly transparent, were plainly seen therein; in another they were found of a brownish Colour, without any apparent Life or Motion.

Monf. *Azout* observed a shining clammy Matter, which stuck to the Shells of Oysters, and being drawn out, shone† in the Air its whole Length, which was four or five Lines, and continued so for a considerable Time when laid on the Observer's Hand, and afterwards opening more than 20 Dozen in the Dark, and then examining some of this shining Matter with a *Microscope*, he found it to consist of three Sorts of real Worms. One was whitish, having 24 or 25 forked Feet on each Side, with a black Speck on one Side of the Head, taken by him for a Crystalline. Its Back like an Eel stripp'd of its Skin; the second was red, resembling the common *Glow-worm*, with Folds on its Back, Legs like the former, and a Nose like that of a Dog's, and one Eye; the third Sort was speckled, with a Head like a Soal, and many Tufts of whitish Hair on its Sides. There was a bigger Species, that was greyish with a big Head, and two Horns like those of a Snail; it had seven or eight whitish Feet, but these shined not.

The two former consist of a Matter easily dissolvable, the least Touch turning them into a viscous and aqueous Matter, which falling from

* *Arc. Nat. Tom. II. Part I. p. 52.* † *Phil. Transf. No. 12. p. 203.*

the Shell, stuck to the Observer's Fingers, and shone there for 20 Seconds. If any Part of it fell to the Ground it appeared like a small Piece of flaming Brimstone, and when shook off nimbly, it seemed a small shining Line, which was dissipated before it reached the Ground. Some of it was whitish, some reddish, but both afforded a violet Colour to the Eye. The Worms give no Light when irritated; and if they do, it lasts but a little while: Whereas in those that are not provoked, it continues a good while.

As tainted *Flesh*, rotten *Wood*, Bodies of *Lobsters*, and some other Kinds of *Fishes*, and other Substances, are sometimes found to shine with a Light resembling the foregoing, may it not probably proceed from the same Cause, viz. from *Animalcules*? Some have also supposed, that the *Ignis Fatuus*, *Will in a Wisp*, or *Jack in a Lanthorn*, is nothing else but a Swarm of minute Insects, that emit Light round them in the Manner *Glow-worms* do.

C H A P. XXVI.

Of the Muscle.

IN a Dissection of the *Ovarium* of a *Muscle*, Mr. *Leeuwenhoek* discovered Numbers of *Embrio Muscles*, * which appeared as plainly in the *Microscope* as the *Muscle* does to the naked Eye; lying with their sharp Ends fastned to the Strings or Vessels whereby they received their Nourishment. These minute *Embrio Muscles* are in due Time laid or placed by the Parent, in a very regular and close Order, on the Outside of the Shell; where, by means of a glewy Matter, they adhere very fast, and continually increase in Size and Strength; till becoming perfect *Muscles*, they fall off and shift for themselves, leaving the Holes where they were placed behind them, as Abundance of *Muscle* Shells when viewed by the *Microscope* can shew. Two or three thousand of these Eggs adhering sometimes to the Shell of one *Muscle*; it is not certain they are all fixed there by the *Muscle* itself, but are frequently placed there by another *Muscle*. The fringed Edge of the *Muscle*, called by Mr. *Leeuwenhoek* the Beard, has in every the minutest Part of it such a Variety of Motions, as is unconceivable; for being composed of longish *Fibres*, each Fibre has on both Sides a vast many moving Particles, which one would almost imagine to be *Animalcules* †.

The Strings or Threads, which we term the Beard, are composed of a Glew, which the *Muscle* applies by the Help of its Trunk to some fixed Body, and draws out as a Spider does its Web, thereby fastening itself,

* *Ph. Tran.* No. 336.
p. 423.

† *Phi. Tran.* No. 336. *Arc. Nat.* Tom. II. p. 19. & Tom. IV.

that it may not be wash'd away. If *Muscles* be put into Salt and Water, they will fasten themselves to the Sides of the Vessel we place them in.

Scallops, Cockles, Limpets, Perriwinkles, and Abundance of other Shell-fish, are Objects that have as yet been very slightly examined by the *Microscope*; and therefore the serious Enquirer into Nature's secret Operations may here be certain of discovering Beauties, which at present he can have no Conception of.

C H A P. XXVII.

Of the Itch.

DOCTOR *Bononio* hath discovered that this Distemper owes its Rise to little *Insects* * under the *Cuticula*, whose continual Bitings cause an Ousing of the Serum from the *Cutis*, and produce those Pustules whereby the Disease is known.

For on observing People, in this Distemper pull out of the Scabs, little Bladders of Water with the Point of a Pin, and crack † them like Lice upon their Nails, from a Place scabbed over, and where there was a grievous Itching, he picked out a little *Pustule*, and from thence squeezed a thin Matter, in which he could but just discern a small white Globule; but on applying it to his *Microscope*, found it to be a minute *Animal* of a whitish Colour, in Shape resembling a Tortoise, but somewhat dark on its Back; it is represented in Fig. 173, at A and B, they have some long Hairs, six Legs, a sharp Head, and two Horns, and are very nimble. He repeated this Experiment on Persons of all Ages, Sexes, and Complexions, and at all Seasons of the Year, and found the same Sort of Animals in most of the watery Pustules; they begin to enter in the Furrows of the *Cuticula* by gnawing and working in their Heads till they are quite got under, where they cause a grievous *Itching*, and force the infected Person to scratch, which only heightens the Malady: From his frequent Observations he also saw one of them drop an *Egg*, almost transparent, from the hinder Part of its Body, and afterwards saw several others of the same Sort, one of which is represented at C, Fig. 173.

Hence follows the Reason why this Distemper is so very catching, since by simple Contact these Animals can readily pass from one Person to another, not only from their swift Motion, but by their clinging to every Thing they touch; and crawling as well upon the Surface of the Body, as under the outward Skin. A few being once lodg'd, they multiply apace by their Eggs; nor is it any Wonder if this Infection is also propagated by the

* *Bonani Micro. p. 91.* † *Ph. Tran. No. 283.*

Sheets, Towels, Handkerchiefs, or Gloves, used by itchy People; since these *Animalcules* may easily be harboured in such Things, and will live out of the Body two or three Days.

This Discovery also accounts why this Distemper is never cured by internal Medicines, but requires *lixivial Washes, Baths, or Ointments*, made up of *Salts, Vitriols, Mercury, Sulphur, Precipitate or Sublimate*, or such kinds of corrosive and penetrating Remedies as can powerfully kill these Vermin in their Skin. It is necessary to continue the Anointing for some Days after the Cure seems perfected; for though the Ointment may have destroyed all the living *Animalcules*, it may not probably have killed their Young in the Eggs, which are laid in Nests in the Skin, which if suffered to be hatched may renew the Distemper.

C H A P. XXVIII.

Of Animalcules in the Teeth.

THESE are to be found in great Numbers of different Kinds, in the whitish Matter, that sticks between the Teeth of *Men, Women, and Children*; * but especially between the Grinders, although they wash their Teeth frequently; but from People that are more careless a Sort of Eels are found. The first Sort A, Fig. 174. move along very swiftly, in Spittle or Water without Bubbles. The second Sort seen at B, Fig. 174. move in the Direction of the dotted Line. The third Sort is seen at E, and the fourth Sort at F.

They all die if Vinegar be put to them; from whence it seems probable, that if the Teeth and Gums be frequently washed with it, it may be a Means to preserve them from these Creatures.

C H A P. XXIX.

Of the Snail.

THIS slow paced slimy Animal hath many curious Observables. The first are its four *Eyes*, like atramentous Spots, fixed at the Ends of its Horns, or rather at the Ends of those black Filaments, or optick *Nerves* † that are sheathed in its Horns, which it can thrust out, draw in, turn, or direct as it finds Occasion. If when the Horns are fully extended, you nimbly clip off their Extremity, and place them before the *Micro-*

* *Leeu. Ex. & Cont. p. 40. Tom. IV.* † *Pow. Mi. Ob. p. 36. Speç. de la Nat. Dialo. XI. scope,*

scope, either upon the Object carrying Glass R, Fig. 2. or stick the End of them with a little Turpentine to the Point, they may easily be examined in the *Universal Microscope*, with all the Magnifiers, and will be found to be two *Hemispherical Eyes*. And when the Stump is re-extended, it will appear evidently hollow, or tubular to the naked Eye.

Snails partake of the Nature of both *Sexes*, insomuch that as soon as one has impregnated the other, the same Act of Generation is immediately returned; each of them, eighteen Days after these Approaches, drop and conceal their Eggs in the Earth; the Young of which, when hatched, appear with Shells compleatly formed *.

If you would view the internal Fabrick of this Animal, the *Microscope* will after a dextrous Dissection discover to you the *Heart*, just against a round Hole near the Neck, which probably is the Place of Respiration, the Heart may be seen to beat near a Quarter of an Hour after Dissection.† Its Guts are green (from the Herbs it eats) and curiously branched over with fine capillary white Veins. This Creature, how contemptible soever it may seem, hath a compleat Sett of the same Parts and Organs with other Animals, as *Heart, Liver, Spleen, Stomach, Guts, Veins* and *Arteries*.

If the Head be cut off, a little Stone will be found, said to be of a diuretick Quality, and of singular Service in gravelly Disorders.

They have a Mouth like a Hare or Rabbit, and Teeth as represented in Fig. 175. whereof A B C shew the upper Jaw, which is white and of a semicircular Form; the lower black Part C D E, hath several prominent Parts or Teeth F F F, but all fixed together so as to compose the same Bone. Mr. *Hook* observed this very *Snail* (of which the Figure now before us is a Picture of its Teeth) to feed on the Leaves of a Rose-tree, and to bite out half-round Bits of the Size and Shape of the Letter C.

If a *Snail* be suffered to creep upon a Bit of Glass, you may by the naked Eye (but better if you apply the Hand-Glass of your Microscope to view it through) observe a little cloudy Stream passing from its Tail to the Head, that never returns the same Way; and this as long as the *Snail* is in Motion.

C H A P. XXX.

Of the Scales of Fishes.

THE outside Coverings of Fishes are *Scales*, formed with inconceivable Beauty and Regularity; some longish, some round, some triangular, some square, and some or other of all the Variety of Shapes imagin-

* *Nat. Delin.* p. 148. † *Pow. Ob.* p. 38.

able: Some again are armed with sharp Prickles, as those of the *Perch*, *Soal*, &c. others have smooth Edges, as the *Cod-Fish*, *Carp*, *Tench*, &c. There is likewise a great Variety even in the same Fish; for the *Scales* taken from the *Belly*, the *Back*, the *Sides*, the *Head*, and all the other Parts are very different from each other.

The *Scale* of a *Soal* Fish is delineated, as it appear'd in the *Microscope*, at Fig. 176. whereof C D E F represents that Part of the *Scale* which shews itself on the Outside of the Fish, and A B C D, the Part which adheres to the Skin, being as it were furrowed, that it might hold the faster, * each of which is terminated on the Outside by pointed Spikes, and every other of these much longer than the interjacent ones.

Mr. *Leeuwenhoek* supposes these *Scales* not to be shed during the whole Life of the Animal; but to have an annual Addition of a new *Scale* growing over the old one, and extending every Way beyond its Edges, in Proportion to the Fishes Growth: Somewhat in the same Manner as the Wood of Trees enlarge yearly by the Addition of a new Circle next the Bark; and as the Age of a Tree may be known by its Number of Ringlets; so in Fishes the Number of Plates† composing their Scales, denote to us their Age.

To prepare Scales for the *Microscope*, take them carefully off with a Pair of Nippers, and wash them very clean, and place them in a smooth Paper, between the Leaves of a Book to make them dry and flat, and then place them in Sliders between the Talcs for Examination.

The *Eel*, *Snake*, *Viper*, *Lizard*, *Slow Worm*, and the *Eft*, &c. afford a great Variety of Scales. The *Dog-Fish Scales* consist of a great Number of horny Points, which appear in the *Microscope* to be curiously ridged or carved.

C H A P. XXXI.

Of Spiders.

THERE are so many different Sorts of *Spiders*, and their Form so generally known, that a Description of them in this Place, cannot be expected. I shall therefore proceed to describe some of those Particulars of this Creature, that are only to be discover'd with the Assistance of the *Microscope*.

Some *Spiders* have six Eyes, others eight, others fewer, and some more. They all seem to be Creatures of Prey, and to feed on other small Insects, but their Ways of catching them are very different. The *Shepherd Spider*

* *Hook's Myc.* p. 162.† *Leeuw. Epist. Physol. Epist.* 24. Mai. 1716.

by running on his Prey ; the *Hunting Spider* by leaping on it ; other Sorts weave Nets, or Cobwebs, whereby they ensnare them. Nature having equipped them both with Materials and Tools, and taught them how to *work* and *weave* their Nets, and lie Perdue, and to watch diligently, and run on any Fly, as soon as ever entangled.

Their Eyes are immoveable and transparent, but not pearl'd ; they are situated in a most curious Manner, and deserve the strictest Examination.

The Way to view them is to cut off the Legs and Tail, and bring only the Head Part before the *Microscope*, upon the Glass R, of Fig. 2. or to stick them upon the Point I, or pinch them between the Nippers of the same Figure, and so apply them to the *Microscope*.

They have all eight Legs, and two Arms, or shorter Legs near their Mouth, that assist in taking their Prey ; they are beset thickly with Hairs, have each six Joints, and end with two hooked Claws, serrated, * or having Teeth on their Inside, whereby they cling fast to any Thing ; and may be often seen to hang down from the Branch of a Tree, on a Thread of their own making, assisted by the Help of these Claws.

Fig. 177. represents Part of the Leg of a *Spider* ; B, C, D, shew the two extreme Claws armed with Teeth like Saws ; E, the third that hath no Teeth. It is certain, that when the *Spider* does not wind itself by its Thread upwards, but runs along its Web, it then takes hold of the spun Thread with this third Claw. This *Spider* had eight Eyes, two of which were on the Top of the Head, to see what passes before him ; below these two others, which look strait forwards ; on each Side of the Head were two more, the two foremost to see collaterally before him, and the two hindmost to see backwards.

Fig. 182. represents that Part of the Head, which contain'd the Eyes separated from the Membrane in which it lay. P Q, the Eyes that look upwards, K L those that look strait forward, I M those that look sideways forward, H N those that look sideways backward. They have no Eye-lids, but are fortified with a hard, polished and transparent Crust : As these Eyes are immoveable, Nature hath indulged them with so large a Number, to give them Information of any Thing that any Ways concerns them.

Every *Spider* is furnished with a Pair of Forceps, represented at A B, and C D, Fig. 183. in the fore-part of its Head. They stand horizontally, and when not made Use of, they let the Claw of them fall down on their respective Branches, like a Knife clasped upon its Haft, as at C D, and there they lie between two Rows of Teeth, that are likewise employed to hold fast its Prey.

- Authors are divided in their Opinions on the Poison of Spiders, some calling these Forceps Stings ; as Mr. *Leeuwenhoek*, who calls the hooked

* *Phil. Transf.* No. 272.

Claws A B and C D Stings; and says, that towards their Extremity at B and C are two small Holes, from whence, according to all Appearance, when it strikes its Enemy, it therefrom ejects a liquid Matter, we call Poison.

He put a Frog and a Spider together into a Glass, and having made the Spider sting * the Frog divers Times, the Frog died in about an Hour's Time.

Dr. Mead believes this to be a Mistake, and that while the Spider bites, a short white Proboscis † is thrust out from the Mouth, which instils a Liquor into the Wound.

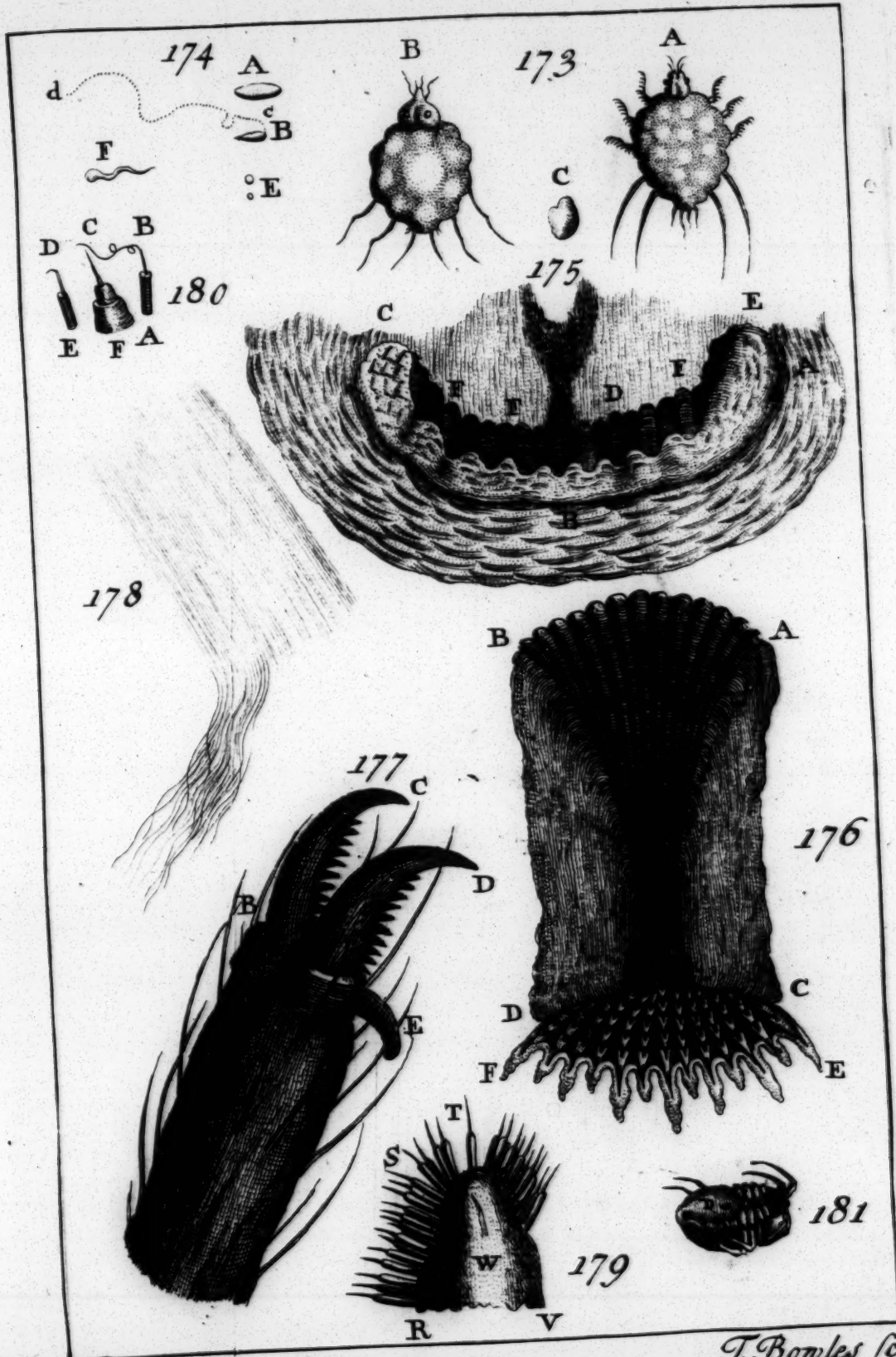
They frequently cast their Skins, which are to be found in Cobwebs, in which the Forceps may be examined, being always shed with the Skins, and easier separated than when alive. They are commonly spread out to View, and by their Transparency, every minute Part is seen with much Distinctness.

The *Microscope* hath also informed us of the Manner how the Spiders weave their *Webs*, and of their *Contexture*, for the Performance of which, Nature hath endowed them with five little *Teats*, or *Nipples*, near the Extremity of the Tail; whence a gloomy Liquor proceeds, which adheres to any Thing its pressed against ‖, and being drawn out, hardens instantly in the Air, and becomes a *String* or *Thread* strong enough to bear five or six times the Weight of the *Spider's Body*; this *Thread* is composed of several *finer ones*, that are drawn out separately, but § unite together at two or three Hair's Breadth distant from the Body of the *Spider*. The Threads are finer or coarser, according to the Size of the *Spider* that spins them.

Fig. 178. represents a Part of the Threads, which came out of two of their working Instruments, and were divided from each other, just as they issued from the Body; and RSTV, Fig. 179. represents one of the four outermost Instruments or Nipples, with its Quills or Reeds, which put together, is not so large as a common Grain of Sand; from whence it is easy to conceive, how small those Instruments must be, and how fine the Threads encased within them: At W these working Instruments stood as thick by each other, as they are represented between R and S. And that Part of the Figure, from the Sight, was not cover'd with those Sort of Quills, but with Hairs only: It is also observable, that a few of these Instruments are bigger than the rest, and consequently produce a larger Thread. CF, Fig. 180. represents one of these between two others of the smaller Sort DE and AB, one of which had a wrinkled or harled Thread.

Spiders emit their Eggs, not out of the hinder Part of their Body, as in all other Animals, but under that upper Part of the Belly, near the hind Legs, where grows a Kind of Hook, of a particular Figure, which partly

* *Phil. Transf.* No. 272. † *Mead* of Poison. ‖ *Phil. Transf.* No. 272. § *Ibid.* No. 325.
covers





covers the Aperture, from whence the Eggs issue. Fig. 181. represents a Spider of an ordinary Size, with its Legs contracted, as if it was dead, in order to shew the above-mention'd Aperture; and at D the Hook is seen.

Fig. 184. G H I K shews the Hook separated from the Spider's Body, as it appear'd through the Microscope; -between I and K are seen the Wrinkles or Folds, which Mr. *Leeuwenhoek* supposes are made to produce a more than ordinary Motion: E F shews the Part that join'd it to the Body, and between F and G are two round Balls. The Use of which he could not discover.

The Eggs of some Spiders are a good Object, being flattish at one End, and round at the other, with a Depression at the Center of the flattish End, and a yellowish Circle round it; their Colour is a blueish white like counterfeited * Pearl; when they hatch, the little Spiders come out perfectly form'd, and very nimble. They deposite their Eggs to the amount of five or six hundred, in a Bag strongly compos'd of their own Web, which the Spider either carries under her Belly, and guards with the greatest Care, or else hides it in some safe Recess. When just hatched, the young Spiders make an entertaining Object for the Microscope.

The Current of the Blood may be seen in the Legs and Body of Spiders, as has been before hinted; many other Wonders will be discover'd by the Curious in the Dissection and Examination of their several Parts.

The Carter, Shepherd, Field, or Long-legged Spider, is different from most other Spiders in two Particulars, the first, which is only discoverable by the Microscope, is the curious Contrivance of its Eyes; it has only two, and those placed upon the Top of a small Pillar, rising perpendicularly out of the Middle of its Back, or rather the Crown of its Head. † The two Eyes, B B, Fig. 185. were placed Back to Back, with the transparent Parts or Pupils more protuberant than the rest of the circumambient Matter, ‖ looking towards either Side, but something more forward than backwards. C, Fig. 187. shews the Column on which they stood, and D D the Crown of the Head.

The second Peculiarity is the prodigious Length of its Legs, which are eight in Number, in Proportion to its small round Body. Each Leg of this, of which the Figures 185, and 186, are a Representation, was above 16 times the whole Length of its Body; they are jointed just like those of a Crab; each of which proceeds from a small shell-like Case, of a conical Figure, as at I I I I, &c. of Fig. 186. which represents the under Part of its Belly, these are fastned on to the protuberant Body of the Insect, forming a Kind of blunt Cone, whose Apex is at M, about which the smaller Cones of the Legs are placed, each of them reaching almost to the Top, in so admirable a Manner, as does not a little manifest the Wisdom of

* *Pow. Myc. Ob.* p. 15.

† *Hook's Myc.* p. 198.

‖ *Pow. Myc. Ob.* p. 14.

Nature's Almighty Architect, in the Contrivance thereof. It has two fore Claws K K tipped with Black like a Crab's, which open and shut exactly like those in a *Scorpion*, and are Saw-like or indented on the Inside. Its Horns are seen at A A and Mouth at L.

The best Way to observe this Spider is to cut off all its Legs, and place it before the Microscope upon the Object carrying Glas R, of Fig. 2, or upon the black and white Object-Plate.

The little white *Field-Spider* with short Legs, found plentifully among new Hay, whose Body appears like white Amber, embossed with black Knobs, out of each whereof grow Prickles like Whippricks, some have six, some eight Eyes, that may be distinctly seen, quick and lively; each Eye has a violet blue Pupil, * clear, and admirably furrounded by a pale yellow Circle.

The wandering or hunting Spider, who spins no Web, but runs and leaps by Fits, has two Tufts of Feathers fixt to its fore Paws, which, together with the great Variety of Colouring all over this Animal, affords a beautiful and delightful Prospect for the Microscope.

There is a red Mite or Louse often found feeding upon Spiders, in Shape much like a Tortoise, † with a little Head, and six long but small Legs; and about the Legs of the Field-Spider they cling exceeding close whilst the Animal is alive, but when dead they all fall off and creep away.

Mr. *Bon* hath made several Pair of Stockings and Gloves, from a Silk ‡ wound off from the Egg Bags of short legged Spiders.

C H A P. XXXII.

Of the Sting and Scraper of a Bee.

AS the Contrivance and Structure of the Stings of most Insects are nearly alike, they will be sufficiently understood by a Description of that of a Bee, as discovered by the Microscope.

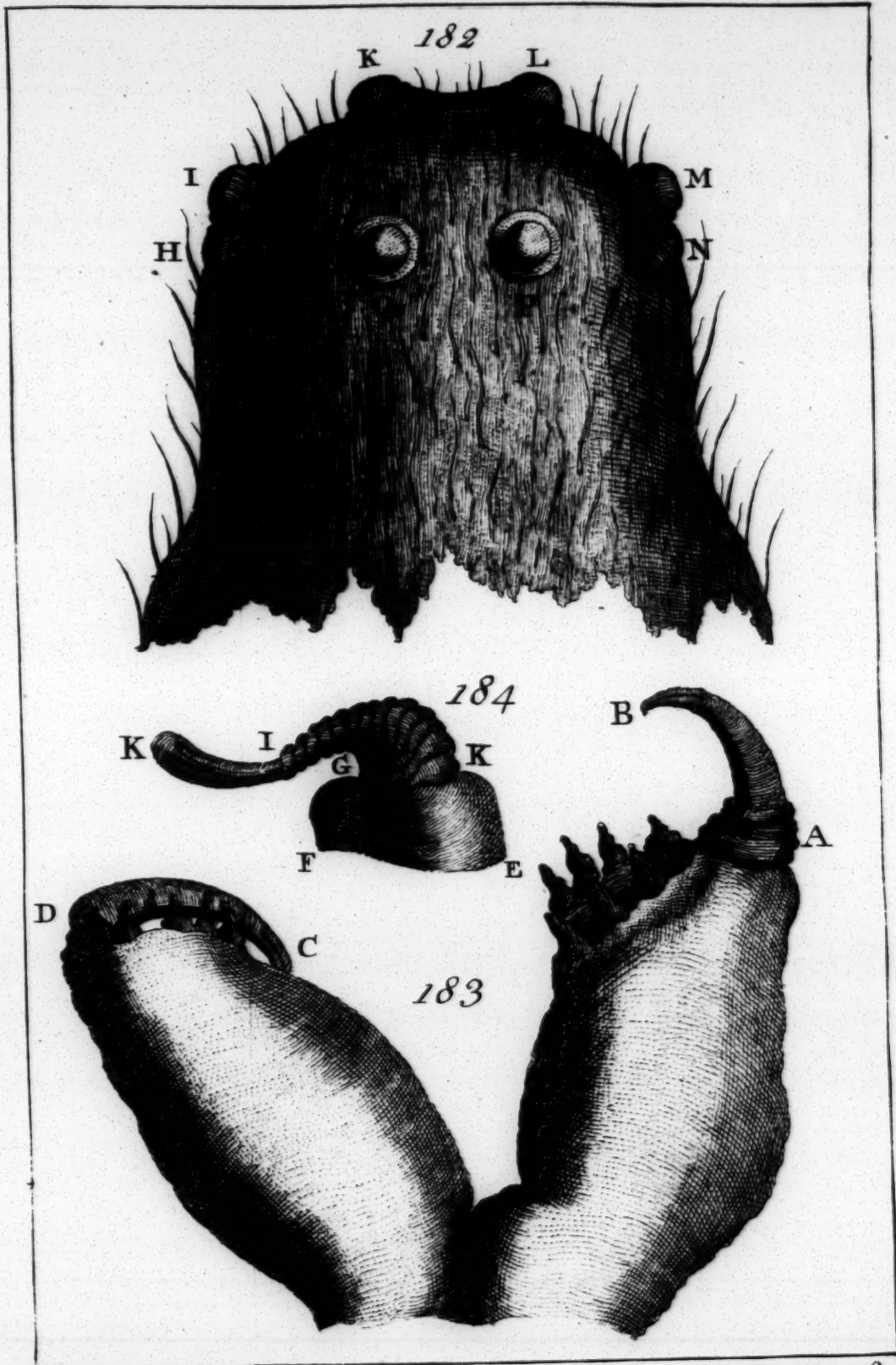
A *Bee's Sting* is a horny Sheath or Scabbard, that includes two bearded Darts; this Sheath ends in a Point, near the Extremity whereof a Slit opens, through which at the Time of stinging, two bearded Darts are protruded beyond the End of the Sheath, one whereof being a little longer than the other, fixes its Beard first, but the other immediately after; they penetrate alternately deeper and deeper, taking hold of the Flesh with their Hooks till the whole Sting becomes buried in the Wound, and then a venomous Juice is injected through the same Sheath, from a little Bag at the Root of the Sting, which occasions an acute Pain, and a Swelling of the Part continues sometimes for several Days after. This is best prevented by

* *Pow. Mi. Ob. p. 13.*

† *Pow. Mi. Ob. p. 19.*

‡ *Phi. Tran. No. 325.*

enlarging





enlarging the Wound immediately to give it some Discharge, and anointing it with a little common Oil.

A B C, Fig. 188. represents the Sheath or Case, out of which the two *Stings* or rather *Spears* are protruded. * E the Cavity, in which they lie. C the Thickness of the Case below; and about C, A, the two *Spears* shew themselves each in a separate Place. Fig. 189, shews Part of the *Sting* taken out of the Sheath, K its Edge or bearded Part, L its Back without Beards. M N, Fig. 190, represents the whole *Sting* taken out of the Sheath with its Back that is without Beards next the Eye; the upper Part M O is inclosed round about and hollow within, the lower Part O P open; P N shews Part of the broken Nerve, Q R is Part of the Body fasten'd to the *Sting*, and placed in the thicker Part of the Case D C A, Fig. 188. A B C, Fig. 191, represents both the *Darts* as they lie together close against the Sheath ||; yet one of them with its Point a little before that of the other, to be ready (as I conceive) to be darted into the Flesh. And Fig. 192 shews both the *Darts* in part out of the Sheath; and one a little higher than the other, as if it were at work.

Fig. 193, represents one of the two *Arms* wherewith Mr. *Leeuwenhoek* thinks the Bee makes her Honey-Combs, and are furnish'd with three peculiar Joints as at D, A, B. Fig. 194, is one of the *Scrapers* placed on the fore Part of the Head, by which she scrapes the *Wax* from *Flowers*. Fig. 195, is the *Wiper* placed forward on the Head, and with it she wipes the *Honey* off the *Flowers*; all which Instruments when the Bee hath done working are skilfully sheathed under her Head. Fig. 196 represents the *Scraper* of a wild Bee.

When the *Darts* are struck deep in the Flesh, if the wounded Person starts before the Bee can disengage them, she leaves her *Sting* behind in the Wound; but if he has Patience to wait until she withdraws the *Spears* into their Scabbard, the Wound becomes much less painful.

If you divide a Bee, especially an *Humble Bee*, § near the Neck, you will see the Heart beat most lively, which is a white pulsing Particle.

Within the yellow Plush or Fur of humble Bees you may frequently find a small whitish very nimble Animal, ** not much unlike the Shape and Form of a Cheese Mite.

The Way to view a Bee's Sting with the Microscope, is to cut off the End of its Tail, and then touching it with a Pin or Needle, it will thrust out the Sting and Darts, which may be snipt off with a Pair of Scissars and kept for Observation; or if you catch a Bee in a Leather Glove, its Sting will be left therein, being unable to disengage its Hooks from Leather: And when it is quite dead, which it will not be till after several Hours,

* *Arc. Nat. Tom. III. Ep. 133. Phi. Tran. No. 97.* || *Derham Ph. Theo. p. 240.*
§ *Porw. Mi. Ob. p. 4.* ** *Ibid. p. 20.*

you may quite extract it with its Darts and Hooks; by squeezing the Tail, pulling out the Sting *, and pressing it at the Bottom, you may likewise push up the Darts; but without some Practice this will be a little difficult.

The poisonous Juice may easily be found in the Bag which contains it; and by letting the Bee strike its Sting upon some hard Body, enough of the said Juice may be obtained to put upon a Slip of Glass, in order to view the Salts floating therein at first, and afterwards shooting into Crystals; or if you gently squeeze its Tail, you may perceive a Drop of this diaphanous Liquor at the very End of the Sting, which if wiped off will be immediately renew'd.

The Stings of Scorpions may be examined in the like Manner.

The Poison of Vipers has also been viewed by the Microscope, but for a Description of this I shall refer the Reader to Dr. Mead's Essay on Poisons.

C H A P. XXXIII.

Of Animalcula in Fluids.

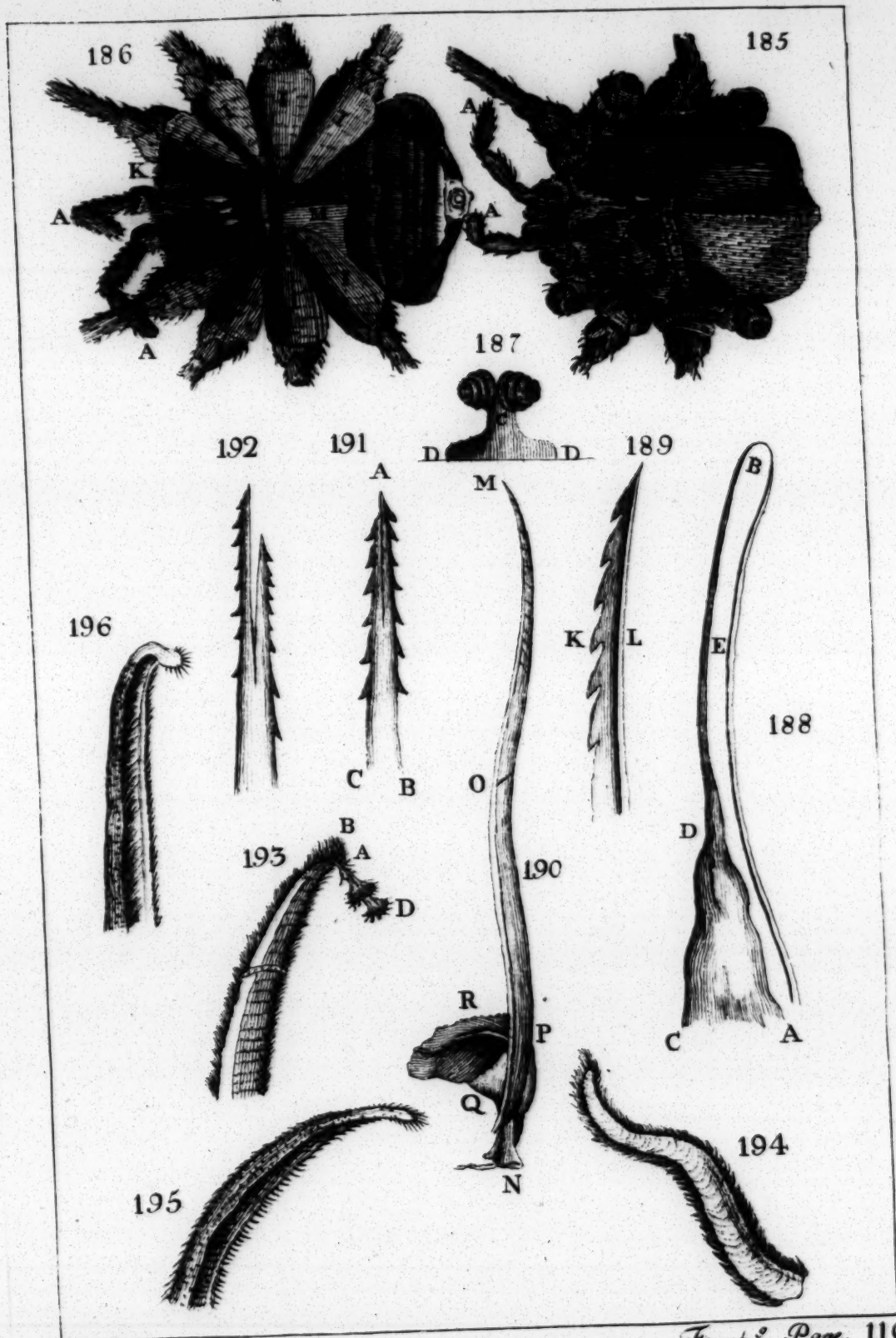
S E C T. I.

THE Microscope hath discovered to us that the smallest of all *living Creatures*, we have been able to trace, are the *Animalcula* in Fluids, which would for ever have remained invisible, had it not been for the Assistance of that Instrument.

If *Pepper, Paste, Vinegar, Hay, Straw, Grass, Oats, &c.* or any other vegetable Production be infused a few Days in Water, exposed all that Time to the open Air; they will abound with inexpressible Numbers of minute living Creatures peculiar to themselves, but of various Forms and Sizes.

Whereof several of the same Species of *Animalcula*, are frequently to be met with in different Infusions, and even in Waters, that have been exposed, especially in *September*, without any Mixture; such have been frequently found therein, as are found in the Cavity of a *Cabbage leaf*, or on the *Dipsacus*, † &c. and that certainly several of these are the same Animals under different Forms, such a regular Process being observed in them, and constant Uniformity in their Appearance, makes it probable that most of them are produced from the Spawn of some invisible volatile Parents, and generated like *Gnats* and several other Sorts of Flies, which are bred and undergo several Changes in the Water before they take Wing; that some of them originally may be Water Insects, or really Fish, small enough to

* *Porv. Mi. Ob. p. 4.* † *Ph. Tran. No. 284.*





Of Animalcula in Fluids.

III

be raised in Spawn with the Vapours, and to fall down again in Rain, and to grow and breed in Water that is kept.

It has been thought that these minute Flies, which hover every Way in the Air, when they find a Fluid stored with a convenient Nourishment for their future Offspring, resort to it in Swarms to lay their Eggs, which being soon hatched, the Animalcula produced therefrom swim about, and live happily, till grown to a certain Size, change their Forms, take Wing and fly away.

If the Infusion is covered only with a fine Lawn or Muslin, few Animalcules will be found therein; but if it stands open it will be full of Life in a few Days: In the least Drop taken from the Surface of such Infusion, the *Microscope* will discover Millions of living Creatures.

S E C T. II.

Of Eels, Serpents, or little worm-like Animalcula, found in Vinegar and Paste.

IF *Vinegar* be exposed to the open Air but a few Days in hot Weather, it will abound with *Eel-like Animalcula*, represented by Fig. 197, two of which are seen at A, making equal Undulations, sometimes four or five are seen to move in the same Manner; at B, B, B, B, are shewn four others differently coiled, they coil and uncoil themselves with a surprising Swiftneſs; at C is a Representation of one with a forked Tail. Monsieur *Joblot* saw but one of these in 36 Years Observation: However, the solar Microscope seldom fails of discovering some of them every Observation. That marked D, although its Mouth seems different from the rest, is not so, but owing to its not being represented in the same Position. They are to be applied to the Universal Microscope, by taking up a Drop of the Vinegar on a Pin's Head, and placing it upon the Object carrying Glass R, Fig. 2. When this Drop begins to evaporate, their Motion will be considerably retarded, at which Time their Mouths may be seen, and many other Particulars may be observed in them.

Some People have imagined, that the Sharpness of the Vinegar, is occasioned by the *Eels* striking their pointed Tails against the *Tongue* and *Palate*; but it is very certain that the sourest Vinegar hath none of those Eels, and that its Pungency is intirely owing to the pointed Figure of its Salts, which float therein.

Animalcula in the Shape of Eels are often found in many Infusions but of a different Size.

* *Joblot's Ob. p. 2. Imprimé à Paris. 1718.*

Dr. Powers observes, that if *Vinegar*, in which these *Eels* abound, be but moderately heated *, they will all die, and sink to the Bottom. But Cold does not hurt them, for after such *Vinegar* had been expos'd a whole Night to the severest Frost, and was frozen and thawed, and frozen again, and so several Times over, they were as brisk as ever: He also tells us, that he put some *Vinegar* full of these *Eels* into an Essence Glass, and pour'd thereon about the same Quantity of Oil, which floating on the *Vinegar*, all the *Eels* would constantly creep up into the Oil, when the *Vinegar* began to freeze, but when it thawed, they as constantly returned to it again.

To furnish yourself with minute *Eels*, always ready for the *Microscope*, boil a little *Flour* and *Water*, till it comes to the Consistence of such *Paste*, as the *Bookbinders* and *Shoemakers* use; expose it to the Air in an open Vessel, and to prevent its hardening, or becoming mouldy on the Surface, beat it well together whenever you find it tends that Way; after a few Days it will turn sour, and then if it be examined with Attention, you will find *Thousands* of those *Eels* on the Surface thereof. To preserve them all the Year, you need only put a little *Water* to them, if the *Paste* grows dry, or a Supply of other *Paste*, always observing to keep the Surface in a right Condition, which will be easily done when it is once stored with these *Animalcula*. Their continual Motion will prevent any Mouldiness thereon.

Apply them to the *Microscope* upon the Object carrying Glass R, Fig. 2. first putting on it a Drop of *Water*, taken up upon the Head of a Pin, for them to swim in, and if the *Paste* be thick, it must be diluted with a sufficient Quantity of *Water* to disentangle the *Eels*, and render them distinctly visible.

They are very entertaining Objects, but more particularly so if examined by the solar *Microscope*, with which they may be magnified to an Inch or more in Diameter. The internal Motion of their Bowels may be very plainly seen, and their Mouths to open to a considerable Width.

S E C T. III.

Of Animalcula in several cold Infusions of whole Pepper.

B D, K, H, O, R, L, Fig. 198. exhibits the first Sort of them, each having several little Spots more transparent than the rest of their Body. The Regularity of the Figure, under which these *Animalcula* generally appear, and the Rapidity of their Motion, prevents us from discovering on

* Pow. My. Ob. p. 34.

what Part of their Body their Head is placed, but after a little Time we are enabled to do it, altho' they continue in Motion; for when the Drop of Water in which they swim, is grown thick by the insensible Evaporation of its subtle Parts, it gradually retards the Motion of these minute Fish; and affords us sufficient Time to observe many Things, that will teach us to admire the Creator's Wisdom, even in the smallest Part of these minute Creatures.

You may then perceive that as two of these *Animalcula* are advancing forward, one moving along the Line from A to B, and the other from C to D, in turning about the first follows the dotted Line B E, and the second moves from D to F.

You may also frequently see that of two of these *Animalcula*, one of them will run as it were along the Line G H, and the other over that of I K, leaving a small Space between them, yet too little for a third L, to find a Passage, which thus inclosed between them, rushes forwards to save himself in the Direction of the dotted Arch towards M. Others after having moved along a strait Line, as H G to O, turn about so swift upon a Point at O, which is their Head, that their oval Figure appears almost circular, after which they launch out with an extremely swift Motion towards P. Others also having run along a Line as Q R, and as it were turning upon their own Center at R, describe several Circles, then shoot forwards with an extraordinary Swiftnefs along the Line S T.

Fig. 199. represents another Sort of *Animalcula*, whose Head is adorned with Hairs, and Motion generally circular, called *Copple Crown* *. A third Sort represented at Fig. 200. called a silver Bag-pipe †. A fourth Sort is a Kind of *Water Spider*, with its Mouth open, as at Fig. 201. Two of them are represented at Fig. 202. conjoined and turning upon their common Center. Fig. 203. shews two more of them also coupled as they swim in a strait Line. Another Sort is represented at Fig. 204. in some Measure resembling a Weaver's Shuttle; its hinder Part is tufted with Hairs, which assist him in swimming. Fig. 205. exhibits a Swarm of exceedingly minute Insects of different Sizes and Shapes, which serve for Nourishment to the larger Sorts.

* *Jobl. Ob. p. 14.*

† These Names were given to the *Animalcula* of the several Infusions, by *Monf. Joblot*, who endeavour'd to call them after the common Names of Things and Animals, to which these *Animalcula* bore some Resemblance.

S E C T. IV.

Of White Pepper.

INfusions made of *whole white Pepper*, produce finer *Animalcula* than the foregoing, but not in so short a Time. The large *Bag-pipe* of this Infusion advances and recedes by Turns, as it swims before the *Microscope*; and just before the Water is totally dried, a great Number of Eggs may be seen within them, and in the next Moment they will be all dried up, and appear like a confused Mass.

S E C T. V.

Of Long Pepper.

Long *Pepper* put whole into common Water, produces *Animalcula* no less surprizing than the two foregoing; in this is sometimes found an *Animalcule* somewhat like a *Caterpillar*; and a different Sort of *Eels*, from those found in *Vinegar* and *Paste*, being thicker and shorter than they, but do not live near so long.

On repeating these Experiments at different Seasons in the Year, and in different Years, other Sorts will be found not here represented.

Take common *black Pepper* grossly pounded, and put it into a Glass Vessel, as much as will cover the Bottom thereof, about half an Inch thick, on which pour about three or four Times that Depth of Rain or River-Water, shake and stir the Pepper and Water well together at first, but afterwards not at all, and expose the Vessel to the Air uncover'd; in a few Days a little Skin may be seen on the Surface of the Water, which, examined by the *Microscope*, will be found to contain Millions of *Animalcula*, at first scarce discernable, but continually increasing in Bulk, till they arrive at their full Size. Their Numbers too increase prodigiously, till at last the whole Surface of the Fluid seems alive.

This Experiment will succeed in Winter, if the Water is not frozen.

The *Animalcula* represented by Fig. 206. are very common, and are described by Mr. *Leeuwenhoek*, who hath seen the Tails of some of them 9 or 10 times longer than their Bodies, * which are about one Third of an Hair's Breadth, but in general they are 4 or 5 times as long. In moving they

* *Phil. Transf.* No. 284.

commonly twitch up their Tail into a screw-like Form, as at b, Fig. 206. and this Spring is so strong, that when the Tail is entangled, as it frequently is by the Extremity, they bring back their whole Bodies by the Jerk and Convolution of the Tail, which quickly returns to its first Straitness. When they lie still, they thrust out and pull back again a bearded Tongue, and a Current constantly runs towards them, occasioned probably by the Motions of some Fins or Legs too fine to be discerned.

Those *Animalcula* exhibited by Fig. 207. abound in all Waters, and are largest of all; their Length is about an Hair's Breadth, and three or four Times more than their own *, they are very thin and transparent, and turn themselves very quick, shewing both Back and Belly, their Edges are adorn'd with a great Number of minute Feet, seen chiefly at the two Extremities; at one End there is a Kind of Brush resembling a Tail; they are swift in Motion, and by their Turns, Returns, and sudden Stops, seem to be continually hunting for Prey. a represents one of them on its Back; b one on its Belly; at c and d, is seen how they often appear in other Positions.

There is generally another Sort of an oval Shape, as at Fig. 208. a b c, lengthening and shortening themselves as Occasion requires, and sometimes two of them may be seen conjoined, as at a.

Another Sort are a Kind of *capillary Eels*, they wave their Bodies but little, move equably and slow, and swim as well backwards as forwards. See Fig. 209.

Several Kinds of Mixtures put amongst them, while they are before the *Microscope*, produce different Effects. The smallest Drop of Spirit of Vitriol, upon the Point of a Pin, being put to them, they immediately tumble down dead; dissolved Salts kill them, but with this Difference, instead of being flat as in the former Case, they shrink into oval Forms. Tincture of Salt of Tartar throws them into convulsive Motions, after which they soon grow languid and die, without changing their Shape. Ink kills them, and so does fresh Blood, Urine, Spittle, and dissolved Sugar †.

There is also another Sort of *Animalcule*, frequently found in this Infusion, of a spherical Figure, only pointed like a Pear, as at Fig. 210. in which are a vast Number of dark Spots, in a confused Agitation, they chiefly turn as it were upon a Center, first one Way, and then the contrary, sometimes they take a large Circuit, but always with their pointed End foremost.

Another Sort represented at Fig. 211. is also found in great Numbers, they move briskly, are very active, contracting, and dilating as they swim along, they have several Feet in their fore Parts very visible; when the Drop of Water is almost evaporated, they shrink up into a globular Form,

* *Phil. Transf.* No. 284.

† *Ibid.* No. 203.

then their Feet standing out, may be seen to move nimbly, a, shews them at their Length, and b when contracted.

Fig. 212. represents another *Animalculum*, not uncommon amongst the rest; its Motion very nimble, always keeping its sharp Extremity foremost; some are clear and ribb'd from the Point to the thick Extremity, others transparent only at the fore Part, as at a and b.

The Water which drains from *Dungbills*, and is of a brown Colour, is generally so prodigiously stored with various Sorts of *Animalcula*, that it must be diluted with Water before they can be sufficiently separated, to distinguish their different Kinds; one particular Sort is found amongst these, which is very rarely to be met with elsewhere, and are shewn at Fig. 213. their middle Part dark, and beset with Hairs, but both Ends transparent, their Tails tapering with a long Sprig at the Extremity thereof, their Motion slow and wadling.

S E C T. VI.

Of Animalcula in a cold Infusion of Senna.

ABout the Middle of *July*, as much as could be taken up with two or three Fingers of the *Leaves*, *Stalks*, and *Branches* of *Senna*, was put into cold Water, and in about eight Days, the Surface thereof was stored with extremely minute longish Bodies, separate from each other, but without Motion. The Corpuscles represented at Fig. 214. were thought to be nothing else but Pieces of the Bark from the Branches of the *Senna*; but in about eight Days after, they all disappear'd, and a surprizing Number of worm-like *Animalcula* succeeded them, but less than the first, being alive, and swimming a little below the Surface of the Water; one of these Worms is seen at Fig. 215. Its Head round at I, its Body compos'd of eleven Ringlets, the lowest Extremity of which ends sometimes in a Plain perpendicular to its Body. At other Times with three round Protuberances, as at M.

Through the Skin there appears a very white Fibre, branching as it were from each Side of the Tail, in a strait Line towards the Head, where they unite in an Arch, as at N, Fig. 216. This Fibre extends and contracts itself alternately, by which Means the Ringlets are drawn nearer to, or pushed farther from each other; Part of the Water being evaporated by its standing several Days. A little fresh Water was poured thereon, which caused the Skin that swam on the Surface of the Infusion to sink to the Bottom of the Vessel; the Infusion was thereby refined, and more transparent than it was before, which occasioned the Discovery of two new Sorts of *Animalcula*, and this in the least Drop that could be applied to the *Microscope*,

croscope, D, and E F, Fig. 217. are their Representatives. The largest of them resembles the Silver Bag-pipe, each having crooked Heads, as at F; they have also two Motions, one strait, and the other circular, slow enough to be easily observed.

Another Kind of fish-like *Animalcula* resembling a *Carp*, is shewn at Fig. 218, its Motion was wrigling as the dotted Line a b c d.

In *January* a great Number of another Sort were found in this Infusion of *Senna*, which ballance themselves from Right to Left as they swim directly forwards. Another Time, after replenishing the Water, other minute *Animalcules* that do not ballance themselves were found therein, and the same Day others also so exceeding small that their Form could not be discerned. A few Days after another Sort shaped like Fig. 219, its Head terminated almost in a Point. After this Infusion had stood a whole Year, another worm-like *Animalcule* was found therein, represented at Fig. 220, whereof A was its Mouth, which was round; from whence issued three Fibres to its forked Tail B B, two other Sorts, as represented by K I, Fig. 221, were also seen in this Infusion.

S E C T. VII.

Of the Water found in Oysters.

A Dozen of *Oysters* being opened, all their Liquor was put into a clean drinking Glass, which in the Space of two Hours appeared to be upon the Fret, and of a fine Pearl Colour, and its Smell like that of the Sea; on applying some of this Liquor to the Microscope after it had stood four Days, a great Number of minute transparent *Oysters* * in rapid Motion were observed therein. a b c d, Fig. 222, represents one of them, of which a is the Head, their Shape altered as they placed themselves in different Positions before the Eye, their Motion was sometimes direct, at others circular. The fifth and sixth Day some of them seemed to be dead; but, on continuing to observe them, were afterwards found to move with a prodigious Swiftnefs, one going one Way, another the contrary, often rubbing and stopping against each other; then being disturbed by others rushing strongly against them, altered the State of their Rencounter, and directed themselves to another Place; they stretch out and shorten themselves considerably, and are often seen coupled as at a and c, Fig. 223, and Fig. 224. Moving together from a towards b, and from c towards d, they turn much slower than those in Pepper-Water, and perform their circular Motion much as they do, turning sometimes on their own Center, and sometimes

* *Jobl. Observ. p. 20.*

on a Point near the Extremity of their Head. This Liquor being observed near eight Days, no other Animals than those of the same Figure could be found therein.

In Fresh Oyster Liquor diluted with common Water, were found Animalcules with two moving Horns in each of their Heads, which formed a kind of Crescent as at e, in others as at d, Fig. 225, but the Horns are so transparent, that they must be viewed attentively, and that for some Time before they can be discovered.

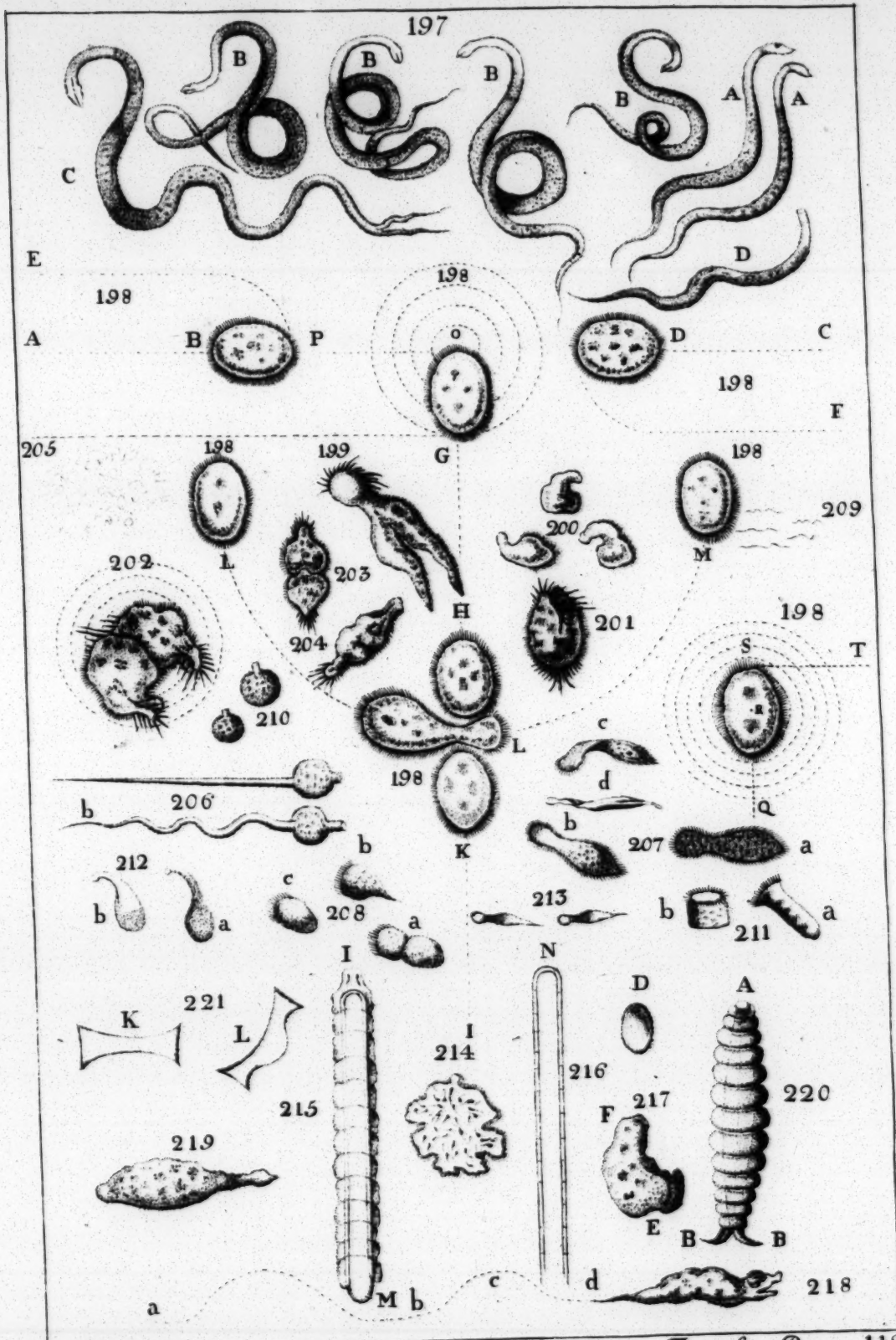
On putting the Liquor of six or seven Oysters into a Glass Vessel one Day at Noon, the next Day at Seven a Quantity of these minute Oysters were found swimming therein, although the Vessel was stopped: Whence it seems not improbable, but that these Animals were produced from the Eggs of the Oysters themselves, and that they do not proceed from other Animals that either fly or float in the Air. Six Days after two different Sorts of new *Animalcula* appeared in the same Liquor; the first are represented at Fig. 226, it stretches itself out and shortens itself alternately. The second Sort is seen at Fig. 227, which moved so slow that the following Particulars were observed; it had four short Legs near its Head, and five longer behind. In the same Liquor was also found another Sort represented at 228.

In other fresh Oyster Liquor were also found different Animalcules, as represented at i, l, m, n, o, p, q, Fig. 229. m exhibits a Worm with a sharp Head and round Tail. Those at n and o shew two of the same Worms joined together, the strongest dragging along the weakest. At p is seen one of another Figure, and at q are two smaller, holding each other by the Beak and swimming in Company.

S E C T. VIII.

Of an Infusion of Pinks made in common Water both cold and hot.

SOME *Pinks* not quite blown being steeped in cold Water, produced living *Animalcules*, which upon Examination with the Microscope were found to be of the Shape represented by Fig. 230. On the sixth Day appeared a larger Sort, but fewer, being very transparent, and strewed with little Spots, Fig. 231. The eighth Day the larger Sort appeared finer and longer than before, and moved after a different Manner; in fifteen Days the Surface of the Liquor was covered with little white Worms, somewhat below which was a prodigious Number of minute *Animalcules*. The 28th Day a large Worm shewed itself under the Form of Fig. 232. The 48th some *Eels*, like those in Vinegar. The 50th Day a little white Worm was taken





taken upon the Surface of this Water, * its Body so transparent, that several little white Fibres were discovered therein, the two middlemost of which being a little separated, and proceeding from the Extremity of the Body, run parallel to each other, and are united by an Arch near the Head: It hath two black Eyes, and two Hooks in the fore Part of its Head, as represented at Fig. 233. At G of the same Fig. is seen another of a curious Form, found also in this Infusion.

Some *Pinks* being infused in boiling Water, which in eleven Days Time swarmed with *Animalcules*, but very small, and on the 15th Day were not to be found, only some Worms might be seen on the Surface thereof with the naked Eye.

S E C T. IX.

Of a cold Infusion made of a Nofegay, composed of Pinks, Roses and Jessamin.

THIS Infusion was made the 11th of May, and the *Nofegay* cut into Pieces for the better placing it in the Vessel, and in about three or four Days a great Number of minute *Animalcules*, and some larger ones, were found therein; their Figures, Colour and Motions are so various, that it would be a Task too long to undertake a Description thereof. Nevertheless I cannot pass over in Silence, an *Animalcule* that was found in this Liquor on the Beginning of September. It consisted of three distinct Parts, Fig. 234. The first Part A is its Head, which advances and retires by Jerks. B, the Trunk of its Body, and C its Tail, it is of a transparent White, and often draws its Tail in, at the End of which are two black Hairs DD.

S E C T. X.

Of an Infusion of Blue-Bottles.

THE Stalks of a large *Nofegay* of *Blue-bottles* with some of the Flowers, were put into cold Water on the second Day of June, and at the same Time some of the *Flowers* by themselves were put into a Glass of Water; in 12 Hours Time the Microscope discovered several *Animalcules* of the Form of Fig. 235, in a small Drop of this Liquor. And the next Evening four other Sorts, very transparent, of an oval Figure, unequal in

* *Jobl. Observ. p. 28.*

Size, and different in their Motion. The 5th of the same Month, another Sort of the Shape of Fig. 236. appear'd therein ; and on the Sixth a new Sort, A B C, Fig. 237. with an oval Head, and a Tail, which terminated in a Point, being five or six times longer than its Body. On the seventh Day, one of these last was observed to drag after it a Bunch of the Sediment of the Infusion, which sunk to the Bottom of the Concave, upon which the Drop of Liquor was placed for Observation. It is very pleasant to behold so small an Animal endeavouring to pull this Bunch about, which he is scarce able to move, as at I, drawing himself back, and wriggling its Tail, as at M. Sometimes five or six of these *Animalcules* may be seen fastened by the Tail, to a great Bunch of this Sediment, that sticks to the Bottom of the Object carrying Glass, drawing themselves nearer to, and retiring farther from it by Turns. During this Exercise, they change their first Figure, and recover it again alternately ; and as their Tail is naturally strait, as at I, they endeavour to drag the Lump after them in a right Line.

It is remarkable, that extremely hot Weather kills them, and in five or six Days they are succeeded by others.

We have no Reason to doubt, but these minute *Animalcules* are furnished with Eyes, for two of the same Figure are often seen to approach each other without touching, and then turning with a prodigious Swiftnefs about their own Center.

Another Sort is sometimes found in this Infusion, whose Extremities are terminated by two plane Surfaces, parallel to each other, as at Fig. 238.

S E C T. XI.

An Infusion of Tea.

HAVING put into the Tea-Pot, as much *Tea*, and a sufficient Quantity of boiling Water, as would make six large Cups, on the 15th of July ; the *Tea-Leaves* which remain'd after the hot Infusion, were put into a large Glass Jar, filled with Spring-Water, and exposed to the open Air for about ten Days ; after which, in the least Drop that could be taken up, when applied to the Microscope, were found a Swarm * of exceedingly minute *Animalcules*, of a round Figure, moving slowly. Some Days after they were fewer in Number, but increas'd in Size, clearer, much more distinct, and of an oval Figure, as at Fig. 239. the Circumference of their Body appear'd black, but all the rest perfectly white and transparent, and now swam with a surprizing Swiftnefs. Their Bodies were of so delicate

* *Job. Obser. p. 34.*

a Consistence, as that their natural Figure was preserved for the Space of two or three Minutes after they were dead.

The 23d of *September*, three other Sorts of more minute *Animalcules* were found in this Liquor, and some of the Eel-Kind also.

S E C T. XII.

An Infusion of Raspberry Stalks.

THIS Infusion is one of them which does not cause a disagreeable Smell, nevertheless it produces in about 24 Hours Time, the finest * *Animalcules* that are to be met with in Fluids, and in as great Numbers. Their Representation is at o o, Fig. 240. they are at first very white and transparent, but more so in some Places than in others, with little Marks upon them, and at length this Whiteness changes into a transparent yellow Colour. They may be seen stretching out, and shortening themselves from oval to round, by Means of Obstacles, which they find in their Way. They are often seen to hold each other by the Beak, and in that Posture they move exceeding fast, without quitting their Hold, as at P. Another Sort of *Animalcule* was found in this Infusion, of the Shape represented at Q; between the Middle of its Body, and the Head, was a transparent Substance, regularly beating, but so quick, that the Shape of it could not be discern'd.

S E C T. XIII.

Infusions of Fennel, Sage, Melon, sour Grapes, Stalks, and Leaves of Marigolds.

Fennel, with its large and small Stalks, was put into cold Water to infuse, *August* 11. and on the 13th following, in the smallest Drop that could possibly be taken up, and placed upon the Object carrying Glass, might be seen a Swarm of an almost innumerable Quantity of little Animals, represented at Fig. 241. amongst which were others of a round Figure, and about five or six times longer.

The 22d of *August*, some Sage Leaves were infused in cold Water, and retain'd their natural Smell all the Time of the Infusion, which was about 12 Days; nothing was seen in this Liquor but some little *Animalcules* † that appear'd no bigger when magnified, than a Grain of Millet does to the naked Eye; and an infinite Number much smaller, that when magnified, appear'd no bigger than the smallest Dot that can be made upon Paper, with the finest Pen, and a little below the Surface of the Liquor, was found three very small but white Worms.

* *Jobl. Obs. p. 35.*

† *Ibid. p. 37.*

The 28th of *September*, in a Drop of this Infusion, was found two Sorts of minute *Animalcules*, represented at Fig. 242.

The 22d of *August*, some *Barberries* were put into cold Water, which produced *Animalcula* of the Shape of T, Fig. 243. in 24 Hours Time.

The 25th of the same Month, a Bit of the *Rind* of a *Melon*, with a little of the *Pulp*, and a few of its Seeds were put into cold Water; the next Morning appear'd some fine transparent *Animalcules*, whose Form is shewn at V, Fig. 243. Many little white longish Bodies were also found therein, whose Figures are seen at X; and other less Bodies marked T, without any sensible Motion.

Some *four Grapes* were also infus'd in cold Water, on the 14th of *August*, and on the 20th, a great Number of *Animalcules* appear'd therein, but so exceedingly minute, that their Shape could not be distinguished; on the 25th two Sorts presented themselves, one as small as the last; the other at Y, Fig. 244. The 4th of *September* these little *Animalcula* were exceedingly multiplied and increased in Size, some of them were join'd together in the Form of a Figure of 8, as at P, Fig. 244. and moved sometimes circular and sometimes in a right Line; on the 8th of *September* were found upon the Crust, which swarm upon this Infusion, some minute Worms, and also in a Drop of the Liquor a considerable Quantity of other Eel-like *Animalcula*.

On the 25th of *August*, some of the Stalks and Leaves of *Marigolds*, were put to steep in cold Water, and eight Days after there was three Sorts of *Animalcula* found therein; the first is represented at Z, Fig. 245. the second at R, of the same Figure; and the last, for which there was no Room in this Plate, were of the Eel-Kind, different from those in *Vinegar*, and different also from those in *Paste*.

S E C T. XIV.

First Infusion of new Hay in cold Water.

THIS Infusion stood but 24 Hours before it was filled with Life, and at the End of five or six Days, in the most minute Drop of this Water, five or six Sorts of living *Animalcula* were discoverable; different in Colour, Size, Figure, and Motion.

The Smell of this Infusion is very strong in hot Weather, but decays as the Infusion grows old, *Animalcules* are very rarely to be met with in any other Infusion that are larger, finer, more transparent, or that live so long as those found in this.

S E C T. XV.

The second Infusion of new Hay.

THE 4th of *October* some new Hay being put into cold Water in two different Vessels, one of which was stopped close with a Piece of Vellum, made very wet, and the other left open: Two Days after, three Sorts of Animalcula were discover'd in each Infusion, and also a sufficient Quantity of them: This Experiment is a Proof, that those Animalcules were produced from Eggs, which had been deposited by their parent * Animals upon the Hay, and also that they were not wafted thither in the Air.

The 10th of the same Month, more of these Animalcula were found in one Drop of that Infusion, which had been covered, than could be seen in the like Quantity not covered.

S E C T. XVI.

The third Experiment made upon the same Hay.

THE 13th of *October* some of the same new Hay was boiled in common Water, above a Quarter of an Hour, and an equal Quantity of it put into two Vessels, nearly of the same Size, one of which was immediately cover'd, even before it was cold, and the other left open, in which was found some Animalcula, at the End of a few Days, and not one in the Infusion, which had been covered; † after which great Care was taken to keep it close for a considerable Time, to try if there were any living Animalcula therein, but none could be found, at length it was left open, and in a few Days, some Animalcules were found therein, which determined that these Animals proceeded from the Eggs of their parent Animals, wafted thither in the Air, since those which had been brought there in the Hay, were totally destroy'd by its being boil'd in Water.

S E C T. XVII.

A Composition of several Infusions mixed together in one Vessel.

T A K E equal Parts of an Infusion of *Senna*, of *Raspberry Stalks*, and of *Hay*, &c. mix these all together, and half an Hour afterwards take as usual a small Drop of this Mixture, which being put upon the Object carrying Glafs,

* *Jobl. Ob. p. 39.*† *Ibid. p. 40.*

and placed before the Microscope, will give you the Pleasure of seeing in this little Drop, the Animalcula of all the Infusions you have mix'd together. * And here it is proper to take Notice, that all these different Animalcula cannot subsist long in this Mixture, each being desirous to remain in its first Infusion, therefore all Sorts of Infusions are not proper to afford the Pleasure of this Sight, for they ought to contain in them something upon which the Animals can subsist.

S E C T. XVIII.

An Infusion of Rhubarb.

Rhubarb is a purgative Drug, and must be a long Time infused in Water, before any Animalcula can be found therein, or any disagreeable Smell, for in about five Weeks there was found only one Sort of Animalcula, which does not merit a particular Description; we shall only say that the Mixture of a Drop of this Infusion, with as much of that of *Senna*, does not destroy the Animalcula in either; and that at the End of 15 Days the Animalcula in the Infusion of *Rhubarb* † were all dead.

S E C T. XIX.

Of an Infusion of Mushrooms.

A Large *Mushroom* being infused in cold Water, produced from one Day to another an astonishing Multitude of infinitely small Animalcules, of a round Figure, which appear'd in a Microscope that magnified twenty-five-thousand times, of the same Size, that a Grain of Rape-Seed does to the naked Eye ‖.

The third Day some of a larger Size were found therein, with a crooked Neck, and very transparent; soon after a third Sort was discovered of an oval Figure, and fluttering Motion.

S E C T. XX.

Of the little Flowers of different Colours that are found in Meadows.

IF some of these *Flowers*, when they are just blown, be put into cold Water, in a few Days a particular Sort of Animalcule will be found therein, resembling the Sole of a Shoe, one of which is represented at Fig. 246. Its Mo-

* *Jobl. Ob. p. 40.* † *Ibid. p. 48.* ‖ *Ibid. p. 48.*

tion is slow, and its Head directly under the Letter A; it inclines itself towards B and C, stretching itself out, and contracting alternately; sometimes all its Body appears as round as a Bowl, at which Time the Surface thereof is uneven: Their Body is marked with longish Spots, and is so transparent, that all their Intestines, and the peristaltick Motion may be distinguished, which are a very agreeable Sight, * These larger Sort appear at the Beginning of the Infusion, but at the End of fifteen Days, a great Number of those represented at Fig. 247. was seen therein, which is contrary to what generally happens in other Infusions, where the smallest appear first.

S E C T. XXI.

Of an Infusion of sweet Basil, which smells like Citron.

THREE Sorts of Animalcules shew themselves in a few Days after sweet Basil hath been infused in common Water; the first are seen at A, Fig. 248. the second at B, and those of the third Sort almost like that represented at C. This last swims in a spiral Line, folding and unfolding its Body every Way.

A, B, C, Fig. 249. represent the Animalcules found in the Infusion of new Hay, the Colour of one, and Figure of the other, was the Occasion of calling one golden, and the other silver Bag-pipe. That Sort represented at D E, are called Clubs; the Head whereof is seen at D. These Animalcules extend and contract, twist and untwist themselves several Ways.

S E C T. XXII.

Infusion of Blue Bottles.

FIG. 250. represents a new Sort of Animalcula found in this Infusion of *Blue Bottles*. A shews the Head, B its Tail, C D its Breadth, which seems divided throughout its whole Length by a curved Line, drawn from B towards A, that Part of the Body marked C, seem'd to be filled with several little Globules, less transparent on this Side, than on that marked D; the Neck of this Animal, which is very long, shortens itself from Time to Time, as does also the hinder Part, marked B. † It swims extraordinary slow, and does not live upon the Object carrying Glass above 5 or 6 Minutes, but two of these were discovered in 5 or 6 Drops, and the second, Fig. 251. was something different from the first, for its Body B C was furnished with little Globules, that render'd it less transparent than the first was, at A B and C D.

* *Jobl. Ob. p. 49.* † *Ibid. p. 51.*

S E C T. XXIII.

Infusion of old Hay.

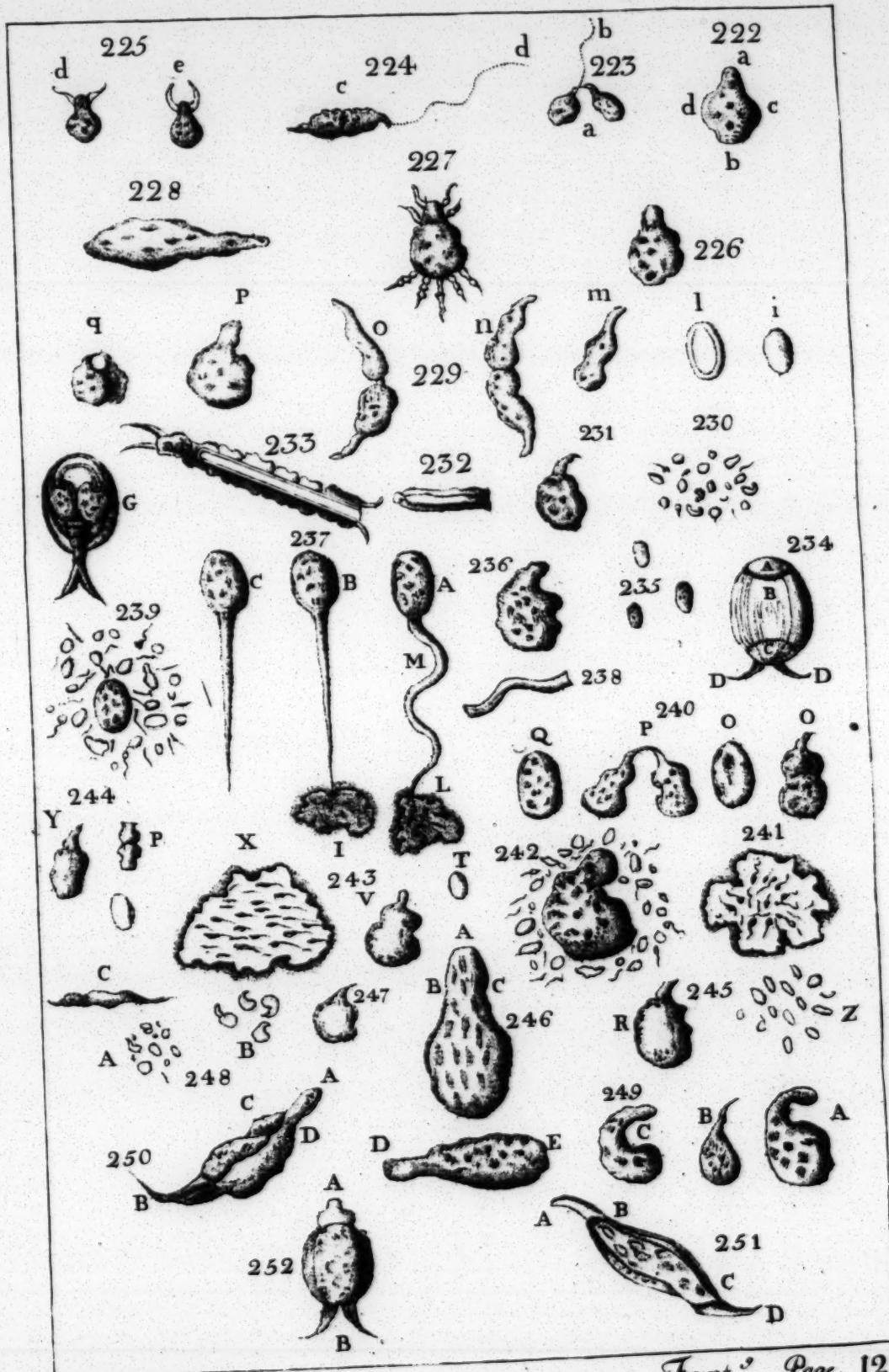
IN this Infusion were two Sorts of Animalcules that merit a particular Description. The least is seen at Fig. 252. it was of a transparent White; A its Head, B its forked Tail, with which it pushes itself forward; and it swims so steadily that no particular Motion of its Body can be discerned.

The second Sort are more extraordinary and surprising, as well in Size as other Circumstances; two of them are represented at Fig. 253 and 254, marked A, C, D B, and A C E F B; A shews the Head, B its forked Tail, C its Heart, which may be seen in a regular Motion, and D its Intestines. It is called an *aquatick Caterpillar*, there are two different Colours of them, one of a transparent White, the other of a pale Yellow. In moving on the Object carrying Glass, they first fix the Points B, and then extending their Body as much as possible, rest the fore Part upon another Place, and draw up the hinder Part, and then again fix the Point B as before and so on; they also fix the Points of their Tail to the Object carrying Glass, and stretch out and retract themselves by Jerks, and sometimes turn round about upon the Point B, at other Times they spring forwards with a sudden Jerk, and swim about for some Time.

When they rest themselves, they commonly open their Mouths very wide as at A, Fig. 254. its Lips also are furnished with Hairs, as expressed in the Figure, which move very quick; it is really surprising to see how hastily they swallow down other smaller Animalcula that happens to be within the Reach of their Mouths. At certain Times all the Hairs at the hinder Part of their Body which stand upright, are seen to lie down from E F to B. The Circumference of the Body seemed indented like the Teeth of a Saw, which upon a closer Examination was discovered to be Ringlets lying one over another, coming out with a surprising Swiftneſs, and sometimes even the nervous Fibres were visible, extending from Head to Tail, swelling and contracting alternately as they crawled along.

A Mixture of the Infusions of Hay and Celery, does no Hurt to either of the Animalcula of the two Liquors; but the least Drop of this Mixture affords a very pleasant Prospect to the Spectator, who will in an Instant discover Variety of these fish-like Animalcules of different Sorts, moving in all Directions.

See also a Design of another aquatick Caterpillar at Fig. 255. it was fished out of an Infusion made of the Stalks of a Nosegay composed of Pinks, Jessamin, Tuberoſe and other Flowers; this differs from the foregoing:





first, in being longer; second, that its Tail marked I, is composed of three Points instead of two; third, that it hath two little Arms LM, one on each Side its Heart a; fourth, that its Intestines marked b are without any visible Separation; and lastly, that neither Ringlets, saw-like Teeth, nervous Fibres, nor Hairs in the Length of its Tail could be discovered in this Animalcule, but in all other Respects it was the same as the foregoing Caterpillar.

S E C T. XXIV.

An Infusion of Citron Flowers.

IN August some of these Flowers were put into cold Water, in a few Days three Sorts of Animalcules were seen therein, which did not merit a figurative Representation. But some Time after others appeared, called Tortoise, one of which is represented at Fig. 256. Its Head, though large, is very short, and adorned with two Horns like those of a Deer: Its Body seemed to be covered with Scales, its Tail very long, and swift in Motion.

S E C T. XXV.

Infusion of Animony.

NAture is pleased to diversify all her Productions, and is surprisingly admirable in all her Works, by continuing to give us Proofs thereof in this Infusion of *Animony* prepared after the ordinary Manner with cold Water, which at the End of eight Days afforded a new Animalcule, represented at Fig. 257. *

All the Surface of its Back is covered with a very fine Mask in Form of a *human Face* perfectly well made, as appears in the Figure. It hath three Feet on each Side, and a Tail coming out from under the Mask.

S E C T. XXVI.

Infusions of three different Portions of Celery Stalks and Leaves, put separately into different Glasses.

ON the 1st of November some of the Stalks of Celery were broke into little Pieces, and put into the first Glas, and common Water poured

* *Jobl. Ob. p. 57.*

thereon,

thereon, and also upon the green Leaves in the second Glass, and in the third Glass some Pieces of the Stalks with some of their Leaves with Water.

Seven Days after these Preparations, some Animalcules were found in each of them, two Sorts in the first, and but one only Sort in both the other : But in about a Month's Time all the three Infusions contained ten different Sorts both in Shape and Size.

Those of Fig. 258, and 259, are the smallest ; but in Number they exceed all the other, when coupled they resemble a Figure of 8, as at a, Fig. 259. These also are called *Bag-pipes* ; they couple by the Beak, which is a little crooked and sharp, and notwithstanding this Coupling they swim very fast, diving to the Bottom of the Drop of Liquor which is placed upon the Object carrying Glass, and rising up again to the Top thereof alternately ; they separate from, and approach each other, without Intermission. These *Bagpipe-like* Animalcules are not entirely alike ; but there is in these as in all other Animals, different Sorts of them.

Some of them swim alone with a surprising Rapidity, while others advance with a moderate Swiftness, some go very slow, and others rest quiet for a long Time together ; but the greater Part of them are in a perpetual Agitation, some of them are long, some short, others as white as Silver, some of a golden Colour, and others brown.

It is a singular Curiosity to observe what passes upon the Surface and all around the Circumference of a Mass of Matter which hath formed itself into a very little Bit of thin Skin, so small, that the best Eyes are not able to see it without a Microscope : They are found by Chance on the Surface of the Infusion, and are generally fastened to the End of the Stalks. If a Bit thereof be taken out with the Point of a Pin, and placed upon the Object carrying Glass before the Microscope, there will be seen Swarms of all these Animalcules we have been speaking of. There are such great Numbers of them moving with so much Celerity, that it is troublesome to turn the Eye upon a Sight so new and surprising. In certain Places thereof there are seen some differently coupled. Others also, that rest themselves, and keep the Watch as Soldiers do, which seem apprehensive of being surpris'd ; whilst others go out a good Way from the Mass as though they would make some Discovery, then they return again as if they had something to relate to those which kept the Watch, and this is seen all round the Mass.

In another Drop, taken from another Place of the same Vessel, has been often seen another new and curious Sight, viz. that Sort of Animalcula which are long and flat, called Soles, and are represented by A B C D, in Fig. 260. The Sides of this Animalcula is very sharp ; the Head and all the rest of its Body is transparent, except a few brown Spots which appear within. The different Postures, and the Variety of Motions observable in these Animalcula, cause much Pleasure in beholding them through a *Microscope*,

eroscope, and afford much greater Satisfaction than can possibly be imagined by reading the most particular Description of them.

In the Glass where only the Leaves were infused, there were amongst others some Animalcules like those expressed at E, F, G, Fig. 261, at one End of each of these Figures may be seen a considerable Opening which is their Mouth, and appears sometimes round as at F, and sometimes ovalish as at E and G; at other Times it is so firmly closed as not to be discovered. It swims by Jolts, and Ballancing from Right to Left, conducting itself in Appearance by a circular Motion of its Head. It also changes its Figure by folding, unfolding, and suddenly rolling itself up in the Form of a Ball, and then alternately stretching out again very quick into its natural State.

There is another Sort of Animalcula that appears to have neither Head nor Eyes, and are represented at H I K, Fig. 262. their Body ends in a long transparent Tail, and Motion generally very slow. They are frequently observed to have a Bit of the Skin (which is formed on the Surface of the Infusion) sticking to their Tail as at L, sometimes they drag it after them, at other Times it happens to stick to the Object carrying Glass, at which Time they draw themselves back on a sudden towards it, and then stretch out again very slowly.

In the least Drop that could be taken up from the third Glass, wherein the Leaves, Stalks, and Roots were mixed, was such an infinite Number of those little Animalcula represented at Fig. 258. that they could scarce find Room enough to pass between each other.

There was also a large oval Animalcule, as at M N, Fig. 263. its Head could not be distinguished.

In a second Infusion of the Leaves of Celery was a new Animalcule, represented at Fig. 264. its Head is seen at O, and is beset with long Hairs that move alternately, its Motion is slow and Figure uncertain, appearing sometimes under the Form of a Bag-pipe, and at others, under that of a Cross.

Fig. 265. represents another Sort of Animalcule of a spheroidical Figure. Another Sort at Fig. 266. and others like Fig. 267. this last moves with a surprizing Velocity, and frequently turns itself upside down.

Amongst other Infusions of Celery, was found an Animalcule in the Shape of a Bottle, as at Fig. 268. Fig. 269. exhibits another Sort of the Bagpipe-like Animalcules, two of which are seen at P, differently coupled from any of the foregoing.

Lastly, at Fig. 270. is represented a most extraordinary Animalcule, almost round, its Body cover'd with Hairs and Motion circular.

S E C T. XXVII.

Of Infusions of Straw and the Ears of Wheat.

IN the Beginning of *March*, some wheaten Straw, and two Ears of Wheat were put into cold Water, the second whereof produced Animalcules, of the Shape of Fig. 269.

Others also were found therein, represented at Fig. 271. its Mouth is seen at A, the Inside of its Body was filled with a Quantity of little white and brown transparent Corpuscles.

A third Sort is represented at Fig. 272. turning according to the Order of the Letters A B C, and moving slowly, its Colour like that of unpollished Silver, strewed with little brown Spots. Its Head is seen at A, Tail at B, and Back at C.

Another Sort of Animalcule is seen therein of an oval Form, and one called a golden Bottle, represented at Fig. 276. its Mouth is sometimes fixed to a round Body, to which it strongly adheres, as at Fig. 273.

Another Sort called *Soals*, contracting and stretching themselves out as they swim along, which is very quick, are represented at Fig. 274.

See also another Sort, at Fig. 275. their Mouth is at A, which is sometimes extended to a great Width. B C is the Tail.

Fig. 277. represents an Animalcule with a Swan-like Neck. A is its Head; B its Tail, and C its Body. They are of two Sorts, one very transparent, and the Inside of the Body of the other brownish. Their Intestines may be seen in Motion.

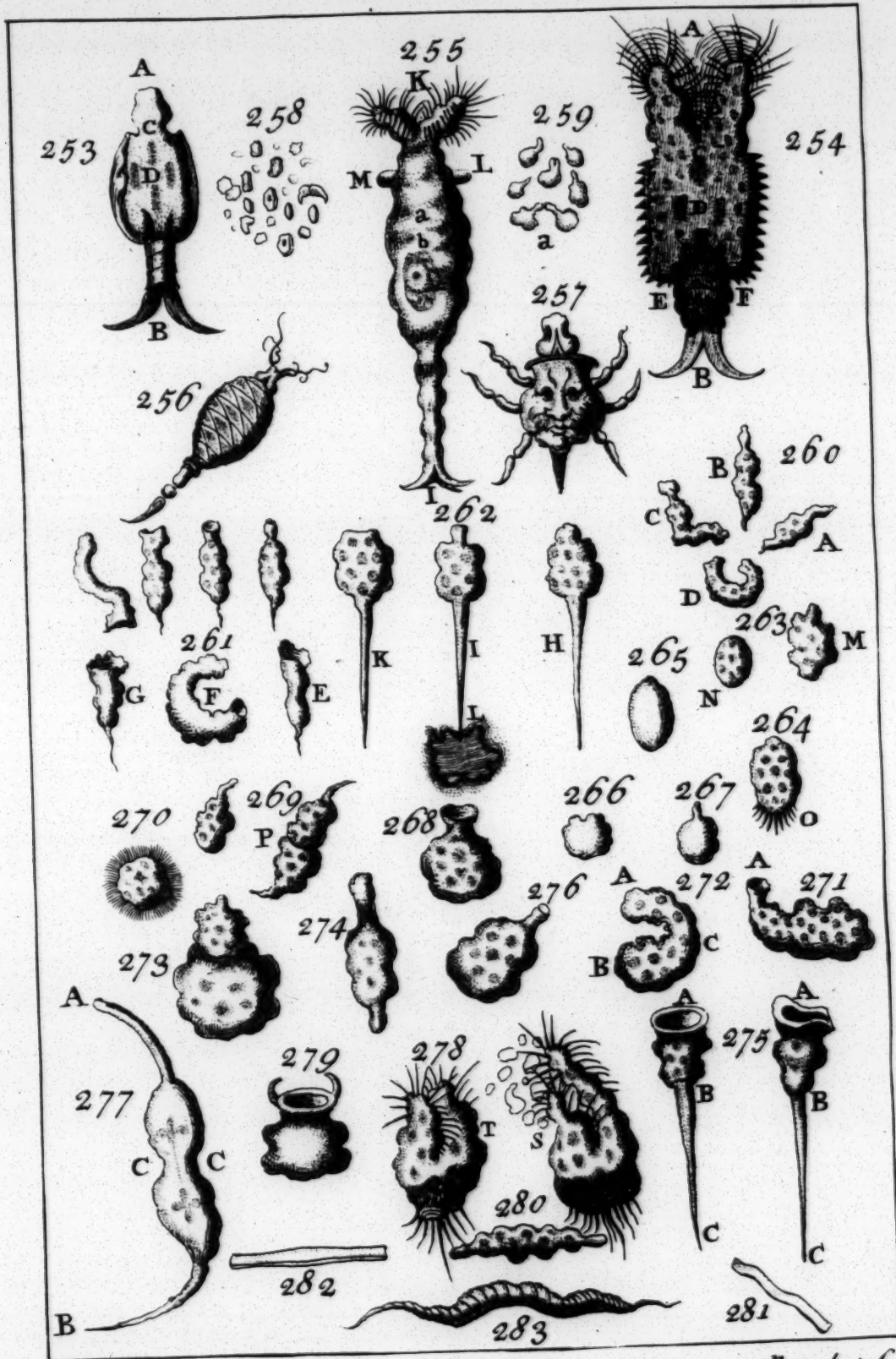
The Animalcula S and T, Fig. 278. are those which were before call'd *Water-Spiders*, or rather *greedy Guts*, from the Quantity of other minute Animalcula they swallow.

That represented Fig. 279. is the only one of its Sort found in the Infusion of wheaten Straw. Its Figure is like a Purse, its Mouth large, and here represented open; but when it stretches itself out for swimming, it is so neatly shut, as to enclose its Horns.

Fig. 280. exhibits an Animalcule, called a *little Soal*; and at Fig. 281, and 282. are two others that move extreamly slow; and are 1000 times smaller than an Hair *.

Fig. 283. represents a Worm-like Animalcule, composed of a great Number of very small spiral Rings, whose Extremities are terminated in very long, and exceeding fine Points.

* *Jobl. Obs. p. 67.*





S E C T. XXVIII.

Of aquatic Pomegranates.

THIS Name of *aquatick Pomegranates*, crowned and bearded, is given to the Animalcula, which are represented by the Figures 284, 285, 286, 287, 288, and 289, because their Shape in some Measure resembles that Fruit; * they were found in a small Drop of an Infusion of wheaten Straw, and seen with a Lens, $\frac{1}{8}$ th of an Inch Focus.

They appear'd of a fine transparent amber Colour, which therefore affords a curious Sight of their Intestines, the several Forms under which this Animalcule appears, require a particular Description, which take as follows:

In Fig. 284. under the Letters A B C D, are shewn four little Eminencies, adorned with Hairs, which remain but a short Time in this Situation, for that marked B joins A, and C unites with D so closely, that they then appear as at A D, Fig. 285. These increased Eminencies, form the separated Lips of this Animalcule, and the regular Motion of the Hairs with which they are adorned, obliges all minute Bodies, at a small Distance from these Lips, to enter into its Mouth. Part of which is also as strongly repelled, as it was greedily swallowed.

All the Protuberances A, B, C, D, of Fig. 284. or the two of Fig. 285. contracting themselves a little towards E, discover a Sort of Crown, with four Points, represented at Fig. 286. which are presently cover'd again with these Eminencies, and then exposed again, and so on.

In each of these Figures, at E, is seen a regular Pulsation, supposed to be its Heart; it seems to be embraced by two Lobes, that separate and join alternately, which probably are the Lungs; from these proceed two little Ligaments at G, towards the Intestines, whose peristaltick Motion is also very regular.

The Tail of this Animalcule appear'd sometimes round and close, at other Times open, when two little Points, as at H, Fig. 284. might be seen.

One of these Animalcules had four of those sharp Points, Fig. 287. placed two on each Side the Anus; between which a long Tail I L is protruded, and drawn in again with great Swiftmess: The End L, in some of these Animalcules, appeared forked, as Fig. 285. the Tail can be entirely drawn into the Body, at which Time the Rings that compose it, slide one over the other, and cause it to become opake.

* *Jobl. Ob. p. 68.*

Their Eggs are frequently seen fastened to their Breech by small Threads; some of the Females carry but one, as at M, Fig. 289. others two, Fig. 285, and some others six, Fig. 286; but this is seldom, and then also they are smaller. They rub their Eggs with their Tail, which as it enters into, and goes out from the Body, turns from one Side to the other with a great deal of Pliableness; those Eggs which are full, appear hanging down, and are very regular and bright, those that are empty are seen quite flat, and of an oval Form, and more transparent than the others, and although empty, their Mothers carry them almost always fastened to their Breech, as at Fig. 286. Two of these Eggs were seen in the Body of one of these Animalcules, and appeared as at G G, Fig. 288.

These Animalcules are a delightful Object for the Microscope, particularly when they tumble over Head and Tail, because they do it dextrously. Some turn themselves circularly, as much on one Side as the other, and about the Point F, which is the Center of Gravity of their Bodies.

S E C T. XXIX.

Infusion of the Bark of an Oak.

SOME of this Bark being put into cold Water, the 15th of *December*, and examined several Times for the Space of a whole Year, during which Time the following Animalcules were discovered. The first was called a Tortoise with an umbelical Tail, Fig. 290. This Insect stretches out and contracts itself very easily, sometimes assuming a round Figure, which it does not retain above a Moment; then opening its Mouth to a surprizing Width, forms nearly the Circumference of a Circle; its Lips are furnished with Hairs, whose Motion is very pleasant, because it obliges some of the adjacent little Bodies, to precipitate into its Stomach, where that which is fit for Food remains, while the other is repelled with great Velocity; its Motion is very surprizing and singular.

Fig. 291. is another Sort of Animalcula with an umbelical Tail, differing only from the former in having its Mouth fixed, and Tail without any Separation.

Fig. 292. represents another of the same Sort, although under a Form somewhat different; the Top of its Head is double, and two Prominencies appear thereon under the Form of Horns, which were intirely covered in the other.

That represented at Fig. 293. is called a Water-Rat, its Head well shaped, and Lips adorned with long Hairs.

Another Sort at Fig. 294. is called a Crab's Claw, because of its two crooked

crooked Beaks, whose Motion as well as that of its Body is very slow, its Body is adorned with a great Number of shining Globules.

Fig. 295. is called a Club, its Head large in Proportion to its Body, which ends in a Point, the Inside of which is strewed with little Grains both transparent and opake.

That Sort exhibited by Fig. 296. is called a Silk-worm's Bag, because its Body is composed of several Rings and longitudinal Fibres, the Shape of its Head is so nearly like that of the Tail, that it can only be distinguished by its Swimming.

The Animalcule, Fig. 297. is called a Spheroid, its Head is seen at A, a little below which may be seen its Heart regularly beating; and several round Bodies of different Sizes, which probably were its Eggs.

There are in this Infusion several Sorts of Eels, different amongst themselves, and different also from those found in Vinegar.

Fig. 298. represents one of them very thick with respect to its Length, which was stored with a considerable Number of exceeding small Fibres, and others also that ran spirally from near its Head towards the Tail.

At Fig. 299. is exhibited another kind of Eel-like Animalcula of great Vivacity.

Another of a larger Size is also represented at Fig. 300. that had been dead for some Time, when by Chance a little Eel* was discovered fluttering very much to get out of the Belly of its Mother, but not being able to do it, at last died therein.

This Observation is a sufficient Proof that the Eggs of these Eel-like Animalcula are hatched in their Mother's Body.

Fig. 301. represents an Animalcule, called a Weaver's Shuttle; it swims smoothly, having in the Middle of its Body several little Corpuscles resembling Eggs.

Fig. 302. is called the Beak of an Halbert, its Head ends in a Point; the other Extremity of its Body is like a Drop, and upon the Throat are several long Hairs.

Fig. 303. is called a Water-Spider, it is of a spherical Figure, with several brown parallel Lines; between which are some Spots browner than the rest of their Bodies.

Fig. 304. is called a Drop, its Body uniform and transparent, its Neck long, but a little crooked.

Fig. 305. is called a Slug, its Head is round, Tail sharp, Body large in Proportion to its Length, and becomes so short in Motion as to appear pretty regular.

Fig. 306. is called a Water Caterpillar, they are found of different Sorts, and in several Infusions of Plants it has been before observed, that the

* *Job. Ob. p. 76.*

Hairs, of which we have elsewhere spoke, are planted on the two Lips of this Caterpillar, which seem to turn at certain Times like the Rowel of a Spur.

Fig. 307. is called the great aquatic Spider, its Figure somewhat ovalish, Mouth a little funk, which appears sometimes to reach to the Middle of its Body, its Lips are adorned with Hairs in Motion, which seem to have a Communication with a little Part that probably may be the Heart, and Lungs surrounding it; its hinder Part is also furnished with Hairs that form a kind of Tail; a little above the Anus is a brown Spot, supposed to be the Excrement; the rest of their Body is generally stored with little regular Corpuscles.

This Sort of Animalcule is also found in Infusions of *wheaten Straw*, in that of *Barley* mixt with some of the Ears; in *Turkey Corn*, *Indian Cane*, in the *Wood* and *Bark* of *Acaias*, or in that of *whole Pepper*, &c. All these different Sorts of Water-Spiders, have Hairs round their Body, inclining a little from their Head towards their Tail, and may be seen with a Lens of $\frac{1}{2}$ of an Inch Focus.

Fig. 308. is called great Mouth, because its Mouth takes up about half the Length of its Body; its upper Lip is much longer than the lower, and are each adorned with little Hairs; its Inside is filled with darkish Spots, and hinder Part terminated with a singular Tail.

Fig. 309, A B C, is named a Funnel, and is here represented under three different Forms, in the middle one the Mouth is open and round, the Inside of its Lips are adorned with little Hairs, which have a quick Motion; the Inside of its Body strewed with many little irregular Spots, and its long Tail generally drags after it little Pieces of Skin fastened to its Extremity. The second is seen at A with its Mouth shut; and the third at C, whose Body is rounder, and its Tail at certain Times twisted in the Form of a Cork-screw.

Fig. 310. hath a Head like Clover Grass, and a forked Tail; its Mouth very small and round.

Fig. 311. is called a Sock, the Inside of its Body is adorned with several transparent Spots, which appear like Eggs.

At the Time this Infusion was intended to be thrown away, it was thought proper to put a Drop of it upon the Object carrying Glass, and to examine it by the Microscope, whereupon one of the most particular of all the foregoing Animalcula was found therein. It is a kind of Water Caterpillar, and so scarce, that no more than seven or eight could be found in many Trials during three Days. Fig. 312. shews three Representations of one of them; in that exhibited by A B, its Body is seen to be composed of several Ringlets, that enter one into the other, as the Animalcula contracts itself; it pushes out of its Mouth a Snout composed of several Pieces sheathed in each other, which are shewn at A C and D. The Extremity of this

this Snout appears to be perforated in some Positions as at D; it is sometimes split in two Parts, at other Times into three, as at A, where they form two or three little Protuberances. At L L are seen two Lips furnished with moveable Hairs. In other Positions not one Hair can be seen. While these Things were observing, a kind of Horn F, was suddenly protruded from its Breast: Its whole Length appear'd to be composed of several Furbelows of unequal Thickneses, which go one into another like the Drawers of a Pocket Telescope: At its Tail are two very sharp Points as at B E, and in some particular Positions it appears in three Parts as at I.

S E C T. XXX.

Infusion of the Bark of a young Oak.

ABOUT the 25th of *December* several little Pieces of the Bark taken from off a Branch of young Oaks were put into cold Water, and in two Hours after some of those Animalcules called Silver Bag pipes was seen therein, and on the 15th of *January* in a very small Drop was seen several new ones. Some of them Mr. *Joblot* called Caterpillars, others Stockings, Stirrup-Stockings, &c.

Those represented at Fig. 313, are called golden Caterpillars, being of an Amber-colour, the longitudinal Fibres are seen from one End of its Body to the other, between which are little irregular Globules.

Fig. 314. is called a Stirrup-Stocking; at C is a great Opening which changed its Shape every Moment, and appeared to be its Mouth; the Lips were sometimes so extended as to serve it for a Rudder to steer its Course, its Body was beset with extremely small Hairs.

That represented at Fig. 315, is in the Form of a Fishing-Net.

Fig. 316. is another, of which the Part G H resembles an ill-shaped Leg, the Middle of its Body appeared to be tied with an invisible Ligature.

Fig. 317, is called a Club, its Mouth intirely close, and Body shaped like one, several little Globules were seen within-side, supposed to be Eggs.

Lastly, at Fig. 318, is one of another kind of the Bottle Sort, which swam amongst the preceding ones; and also a great Number of other Sorts which do not merit a Description. The cold Weather increased so fast, that in 15 Days Time all the *Animalcules* in this Infusion were destroyed.

S E C T. XXXI.

Of some other larger aquatic Animals.

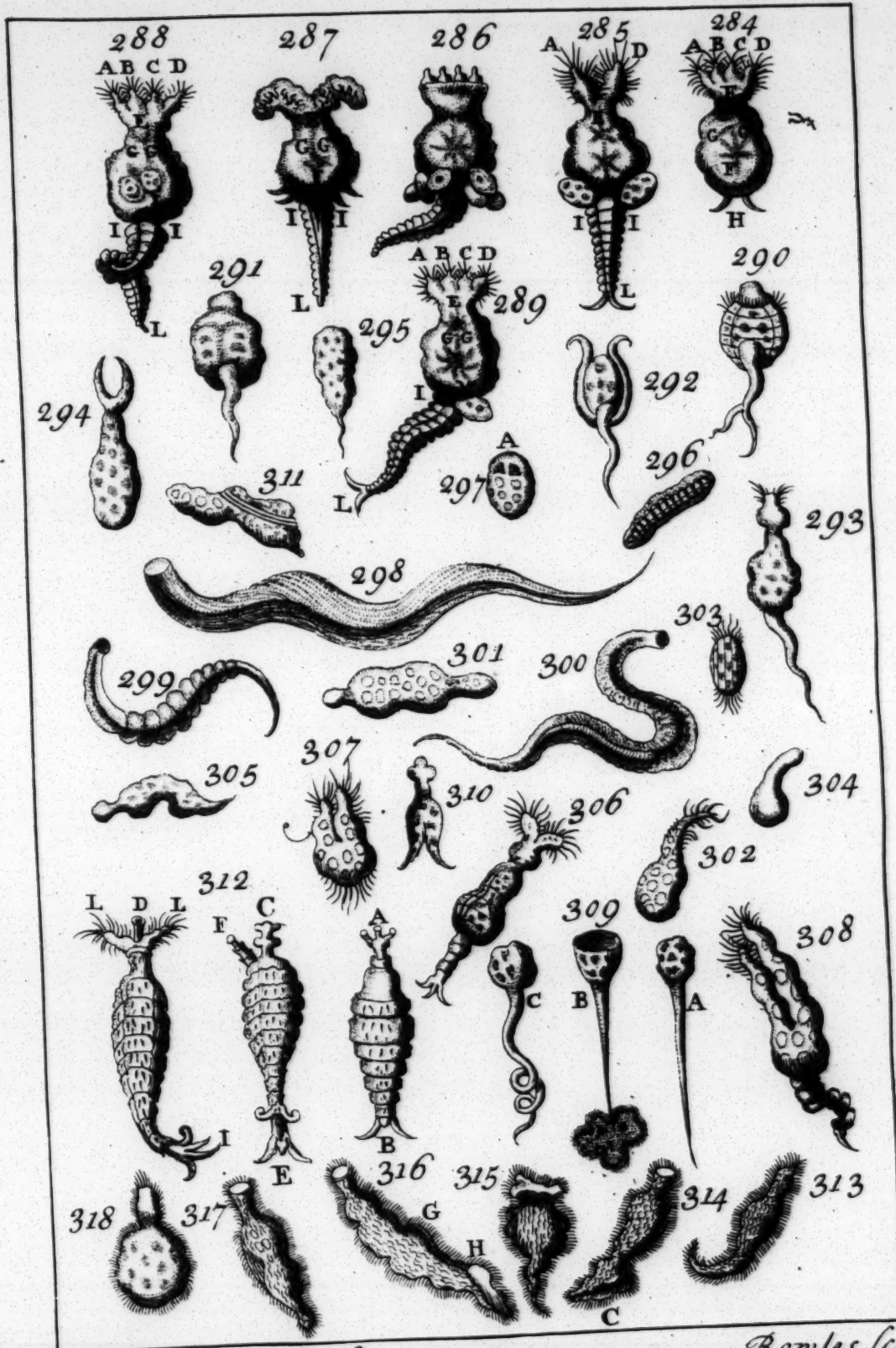
TH E *Waters* every where are stocked with Life, which makes the Subject endless for the Employment of the Microscope, *Seas, Rivers, Ponds, Ditches*, and almost every *Puddle*, can present us with living Wonders; but as these Examinations have been very little attended too even by those who are supplied with Microscopes, I hope these Directions and the new *Universal Microscope*, will be a Means to whet the Inclinations of the industrious Enquirer, the Difficulties in the Use of the common Instruments being here removed.

Mr. *Leeuwenboek* found some surprising *Animalcules*, adhering to the *Lens Palustris* * or *Duck-weed*, which he examined in a Glass Tube filled with Water; one Sort of these were shaped like Bells, with long Tails, whereby they fastened themselves to the Roots of these Weeds. HM, Fig. 319, represents a small Part of the Root as it appear'd in the Microscope, supposed to be almost withered and over-grown, with a great many long Particles which are seen between K and L. The *Animalcula* representing little Bells, † are seen at I S T.

On several of these Roots were observed one, and sometimes two Sheaths or Cases of various Sizes, fastened thereto by the small End: The largest is exhibited at R X Y, out of which Sheath appeared a little Animal, whose fore Part was roundish as at X Y Z, from whence proceeded two little Wheels that had a swift Gyration always one and the same Way, and were thickly set with Teeth or Notches as at P Q R S. When they have for some Time exerted their circular Motion, they draw the Wheels into their Bodies, and their Bodies wholly into their Sheath, and soon after thrust themselves out again and renew the aforesaid Motion. Mr. *Leeuwenboek* observed the Case of one of these *Animalcules* to be composed of round Bubbles, ‡ as is represented at N, O, T. When this Animalcule had thrust that Part of its Body from O to P, out of its Sheath N O; it extruded at the same Time that surprising Wheel-work (which before was taken for two distinct little Wheels, and was here plainly seen to be but one and the same Circumvolution) that consisted of four round Parts P Q R S, three of which were to be seen, the fourth being almost hid; its Motion was from P to Q, according to the Order of the Letters. Fig. 320, represents the Wheel-work by itself, and larger than it appeared to the Sight.

Mr. *Leeuwenboek* found several Kinds of these Wheel-work Animalcula,

* *Phi. Transf.* No. 283, 295, 337. † *Ibid.* No. 283. ‡ *Ibid.* No. 295.



Fronting page 136.

Bowles sc.



in the slimy Matter which is to be found in leaden Pipes, or * Gutters, when the Water dries away they contract themselves into an oval Figure, and a reddish Colour, and become fixed in the dry Dirt, which grows as hard as Clay; but if to this Dirt you put Water, in about half an Hour's Time they open, and by Degrees extend their Bodies and swim about; and this they did after some of this Gutter-dirt had been kept dry for 21 Months together: Whence he concludes, that the Pores of their Skin are so perfectly closed as to prevent all Perspiration, by which Means they are preserved till Rain falls, when they open their Bodies, swim about and take in Nourishment.

Fig. 321 and 322, represents two of them in different Positions, and Fig. 323 shews how they appear when dry and contracted.

Several Species both of crustaceous and testaceous Animalcules are to be found in the Waters of Ditches; two of the former Sort are represented in Fig. 324 and 325, in the Posture they swim with their Backs next the Eye, their Legs are something like those of Shrimps or Lobsters, but of a Structure much more curious; they are less than a very small Flea, are all Breeders † and carry their Spawn in two Bags, which hang from their Sides, or under their Tail, as in Fig. 325. These Bags are sometimes seen broke, and the Spawn scattered about the Water. There is a third Sort amongst these as beautiful as the foregoing, but not near so large; its Shape nearly resembles a Shrimp, and carries its Spawn as the Shrimp does. These three Kinds of *Animalcula* have but one Eye, and that placed in the Middle of their Forehead; they are often to be found so transparent, that the Motion of their Bowels is very plainly discovered by the Microscope, together with a regular Pulsation in a little Part, which we may suppose the Heart.

In the Summer-time it is common for the Water in Ditches to appear sometimes of a greenish, and sometimes of a brownish Colour, which upon Examination by the Microscope is found to consist in infinite Numbers of *Animalcula*, blended together on the Surface of it, and giving it such an Appearance; their Shape is oval, but the Middle either green or red, and seems to be composed of Globules, resembling the Roes or Spawn of Fishes.

* *Leeuw. Arc. Nat. Tom. II. Epist. 149.* † *Phil. Transf. No. 288.*

C H A P. XXXIV.

Of the fresh Water Polipe, with Arms in Form of Horns.

S E C T. I.

Of their Motion and Structure.

THE Nature of this Insect is both extraordinary, and contrary to the general received Opinions of Animal Life, and requires the most convincing Proofs to persuade many People into a Belief thereof. In order therefore to clear up this peculiar Affair, I shall lay before the Reader the following Observations, which were made by Mr. Trembley, and also assure him, that I have repeated the major Part of his Experiments on this Animal with the same Success.

And first these Animals were not hitherto entirely unknown, for Mr. *Leeuwenhoek* gives a Description of a surprising Sort of minute Animal, in the *Philosophical Transactions*, Number 283. It is represented at Fig. 328, as it appeared fastened to a Root of *Duckweed*, whilst in the Water, and about three Times bigger than it appeared to the naked Eye; this was a large one of the Sort, and had eight Horns: At C is shewn a very small *Animalcule* coming out of the other's Body, supposed at first to be fastned thereto by some Accident; but on a closer Examination, was found to be a young one in the Birth, although it had at first but four small Horns; after 16 Hours its Horns and Body was grown much larger, and in four Hours more was quite excluded its Mother's Body; against this on the other Side appeared a little round Knob, which gradually increased in Bigness, and in a few Hours was pointed as at D, Fig. 328; about 14 Hours after it was grown much larger, and had two Horns; three Hours after it also fell off from its Mother and shifted for itself.

An *English* Gentleman * discovered one of them in some clear Water taken out of a Ditch; but with the utmost Attention he could find no more therein. It appeared the first Day as at Fig. 326, but varied every Moment, and the Knob at a, looked like the Gut Cenum; two or three Days after he observed some white Fibres at the Extremity of the Knob; on the fourth it was extended at full Length, and appeared as Fig. 327; which then convinced him this Excrecence was really an *Animalcule* of the

* *Phil. Transf. No. 288.*

same Species, having six Horns; next Day he found it separated from its Mother; it is seen in its contracted State as delineated by this Gentleman at Fig. 329 and 330.

There is a near Agreement between the Observations of these two Gentlemen, both of them having discovered the most remarkable Property of the *Polypes*, that is to say, their *natural* Manner of *multiplying*. They have also given us their exterior Figure, and some of their Motions; but their more surprising Properties, were reserved for the Discovery of the *inquisitive* and *happy Genius* of Mr. *Trembley*. It was also known to several other Gentlemen before him, but none of them discovered this *remarkable Re-production*, which is found in the *different Parts* of a *Polype* after they are *separated*, each distinct Piece becoming as perfect an Animal as that of *which* it was only a *Part*.

Mr. *Trembley* having taken Notice of some Plants, which he had taken out of a Ditch, and put into a large Glass full of Water, and employing himself in considering the Insects therein contained, he cast his Eye upon a *Polype*, which was fix'd to the Stalk of an aquatick Plant, and is represented at Fig. 331.

Their Bodies *a b* are very small, and from one of their Extremities at *a*, proceed several Horns *a, c*, which serve them for Feet and Arms, and are much smaller than their Bodies. I call the Extremity *a*, *anterior*, because it is the *Polype's* Head; and the opposite Extremity *b* *posterior*.

The first Sort of *Polypes* Mr. *Trembley* found, were of a fine green Colour, and in the Posture of those represented by Fig. 331. The first Motion he observed in them was that of their Arms, which they extend and contract, bend and wind divers Ways; they also contract their Bodies upon the least Touch, so short that they appear only like a Grain of Matter. They constantly turn themselves towards the Light; for if that Part of the Glass in which they are, be frequently turned from the Light, they will be found the next Day to have removed themselves to the light Side of the Glass, the dark Side being quite depopulated.

For Mr. *Trembley* inclosed a great Glass well stored with green *Polypes*, in a *Paste-board Box*, which had a Hole cut on one Side in the Form of a *Chevron*, that exactly answered to the Middle of the Glass in which the *Polypes* were: When this Hole was turned to the Light, it always happened, that the *Polypes* assembled themselves together at that Side of the Glass, and also in the Form of the *Chevron*; although the Glass was turned several Times in this Box, yet at the End of a few Days the *Polypes* were always found ranged as before. To vary this Experiment, he turned the *Chevron* upside-down, and notwithstanding this, the *Polypes* always assembled themselves together, and in the Form of the *Chevron*, whether *right* or *inverted*.

The 25th of November 1740, Mr. *Trembley* cut a *Polype* transversly (for
T 2 the

Of the fresh Water Polype.

the first Time) but the Head Part a little shorter than the Tail Part, and put the two Parts into a flat Glass, in which the Height of the Water did not exceed a quarter of an Inch, by which Means they might be easily observed with a pretty deep magnifying Glass.

In that Instant the *Polype* was cut, both Parts contracted, and sunk to the Bottom of the Glass, like two little Grains of green Matter. Some few Hours after both the Parts stretched themselves out, and were easily to be distinguished from each other, the anterior End of the first being furnished with Horns, whereas the other had none at all.

The first Part moved its Arms, and the next Day he saw it change its Place in the Glass, and both were observed to extend and contract themselves for several Days.

He only looked upon the Motion of these two Parts, as Signs of the weak Remains of Life, especially with respect to the hinder Part, and therefore observed it only to know how long it would remain alive, not in the least hoping to be the Spectator of this *so marvellous a Re production*.

But observing the cut Pieces on the 9th Day with a magnifying Glass, perceived three little Points coming out from the Edges of the anterior End of the second Part, which had neither Head nor Arms. The next Day he was convinced they were Arms, and the Day following *two new Arms* came out, and some Days after *three more*; this second Part had then *eight*, which in a little Time was as long as those of the first Part, so that now there was no Difference between the second Part and a *Polype* that had never been cut. They both appeared sensible, being each of them compleat *Polypes*, and performing all the known Functions of *stretching* themselves out, *contracting* and *walking*.

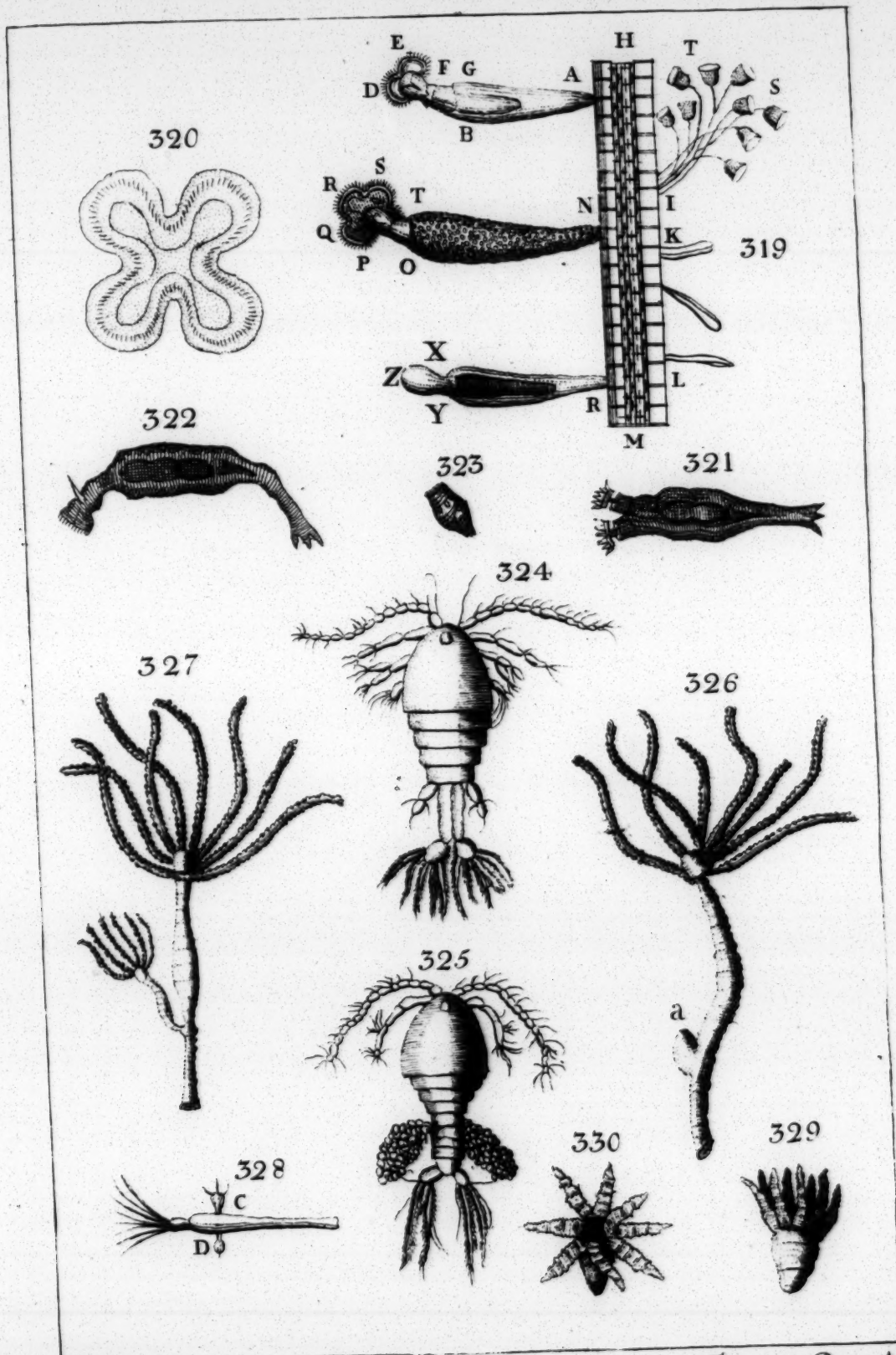
After this he discovered one in a great Glass he had by him, which was well stored with green *Polypes*, from which young ones began to shoot.

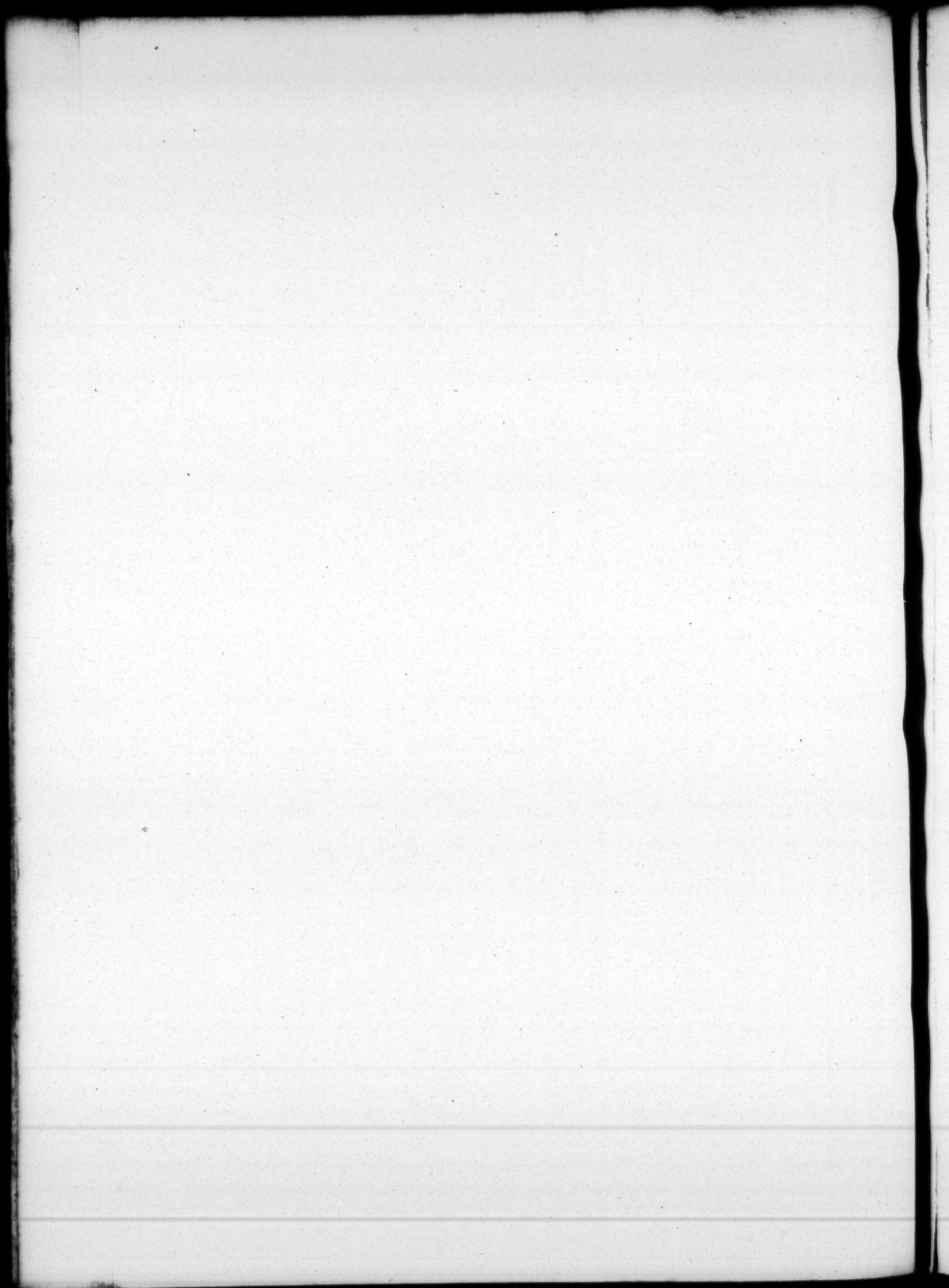
In the Month of *April* he found a new Sort of *Polypes*, represented at Fig. 332. and soon after saw them *eat* and swallow down *Worms longer than themselves*, and to digest them and be nourished therewith: Therefore this is a certain Proof of their being *Animals*.

They are to be found indifferently upon all Sorts of *aquatick Plants*, and other Bodies that are in the Water (upon which they fix themselves by the *Tail*) at the Bottom of *Ditches*, and are suspended upon the Surface of the Water, upon *Branches of Trees, Boards, rotten Leaves, Bits of Straw, Stones*, and many of them Mr. *Trembley* hath found on the Bodies of divers *Animals*, as on the Shells of Snails, &c.

The best Way to find them, is to take up these different Bodies and put them in Glasses full of Water, and if there are any *Polypes*, they will soon be perceived adhering to those Bodies and moving their Arms.

Mr. *Trembley* hath also taken the Trouble of going often to the Sides of the *Ditch* in which he found them, at a Time when the Sun shone upon the





the *Bottom* of the *Water*, and chose those *Places* where the *Water* was *clear*, and that had an easy Declivity, and says, he hath distinctly seen them at the *Bottom* of the *Water*, on all the *Bodies* that were therein, and on its *Superficies*; by which *Means* he acquired those *Ideas* concerning them, he could never have attained to without this *Precaution*.

The most common Posture they are generally found in, whether in their ordinary *Places* of Abode, or in *Glasses*, is represented by the *Figures* 331, and 332. The *posterior* End *b*, of the *Polype* *a b*, is fixed against a *Plant* *e f*, *Fig.* 331, or against a *Straw* *g h*, *Fig.* 332, the *Body* *a b*, and *Arms* *a c*, being extended in the *Water*.

The general *Figure* of the *Polype's* *Body* in this *Attitude* is not perfectly the same; in the three *Kinds* of *Polypes* here described, the *Body* of the green ones, *Fig.* 331. diminish from their *anterior* to their *posterior* End, the *Diminution* being almost insensible.

That Sort represented *Fig.* 332, are the same; but those of the third Sort, *Fig.* 333, differ from the two preceding ones in this *Respect*, that their *Body* does not diminish insensibly, but from the *anterior* Extremity *a*, to the Part *d*, and sometimes even to two Thirds of the *Length* of their *Body*; as at *d*, *Fig.* 334, becoming from this Point much finer, and do not diminish from thence to the *posterior* End. They wave their *Arms* in all *Directions*, as at *a*, *i*, *k*, *Fig.* 331, at *a* and *e*, *Fig.* 332. and at *a*, *Fig.* 333 and 334. The *Number* of their *Horns* in these three Sorts of *Polypes*, is generally at least six, and at most 12 or 13, yet nevertheless there are some few of the second Sort which have 18 *Arms*. They can contract their *Bodies* till they are not above the 10th of an *Inch* or thereabouts in *Length*: For Example, that represented at *Fig.* 333, could contract itself so as to become like those two *Representations* *Fig.* 335. They can also stop at any *Degree* either of *Extension* or *Contraction*, from the greatest to the least.

The green ones are generally about half an *Inch* in *Length* when stretched out. Those of the second and third Sort are most commonly between $\frac{3}{4}$ of an *Inch* and an *Inch*; but some may be found of both Sorts, whose *Bodies* are an *Inch* and half long.

They grow smaller as they extend, and increase in Bulk as they contract themselves. The *Figures* 331, 332, and 333 represent the general and natural *Size* of these three Sorts of *Polypes*; and at *Fig.* 362. is an exact *Representation* of one, as it appears in the *Microscope*.

You may oblige them to contract more or less, in *Proportion* as they are touched, or as the *Water* in which they are, is agitated more or less. Every *Polype*, when taken out of the *Water*, contracts itself in such Sort, as to appear like a mere *Lump* of *Jelly* on the *Body* it is fastened to, as at *Fig.* 336. which *Figure* is so different from what it bears when stretched out, that it can scarce be known at first *Sight*, but when the *Eye* is once accustomed to it, they are easily distinguished from all other *Bodies* that are out of the *Water*.

Heat and *Cold* hath the same *Effects* on the *Polypes*, as it hath upon all other *Land* and *Water Insects*. *Heat* animates, and *Cold* benumbs, or makes them *faint* and *languid*; yet nevertheless it requires a considerable Degree of *Cold*, to reduce them to a *motionless State*, and that must be very near to that of *Freezing*. At which Time they are more or less contracted, and so remain; but as soon as the Water in which they are, acquires some Degree of Warmth, they stretch themselves out, and move proportionably to the Heat thereof. It is not necessary that this Degree of Heat be very considerable, but is sufficient for them, if the Water be of a *temperate Heat*, which is exactly shewn by the 48th Degree on *Farenheid's Thermometer* *.

The Arms of the green *Polypes* seldom exceed the Length of their Bodies, as at Fig. 331. An Inch is commonly the Length of the Arms of the second Sort, as at Fig. 332. tho' some are longer. The Arms of the third Sort are generally about eight Inches, Fig. 333. for which Reason Mr. *Trembley* calls them *long arm'd Polypes*.

The *Polype* can extend and contract its Arms, without extending or contracting its Body; and its Body, without any Alteration in the Arms, it can also extend and contract all or some of its Arms, independant of the others.

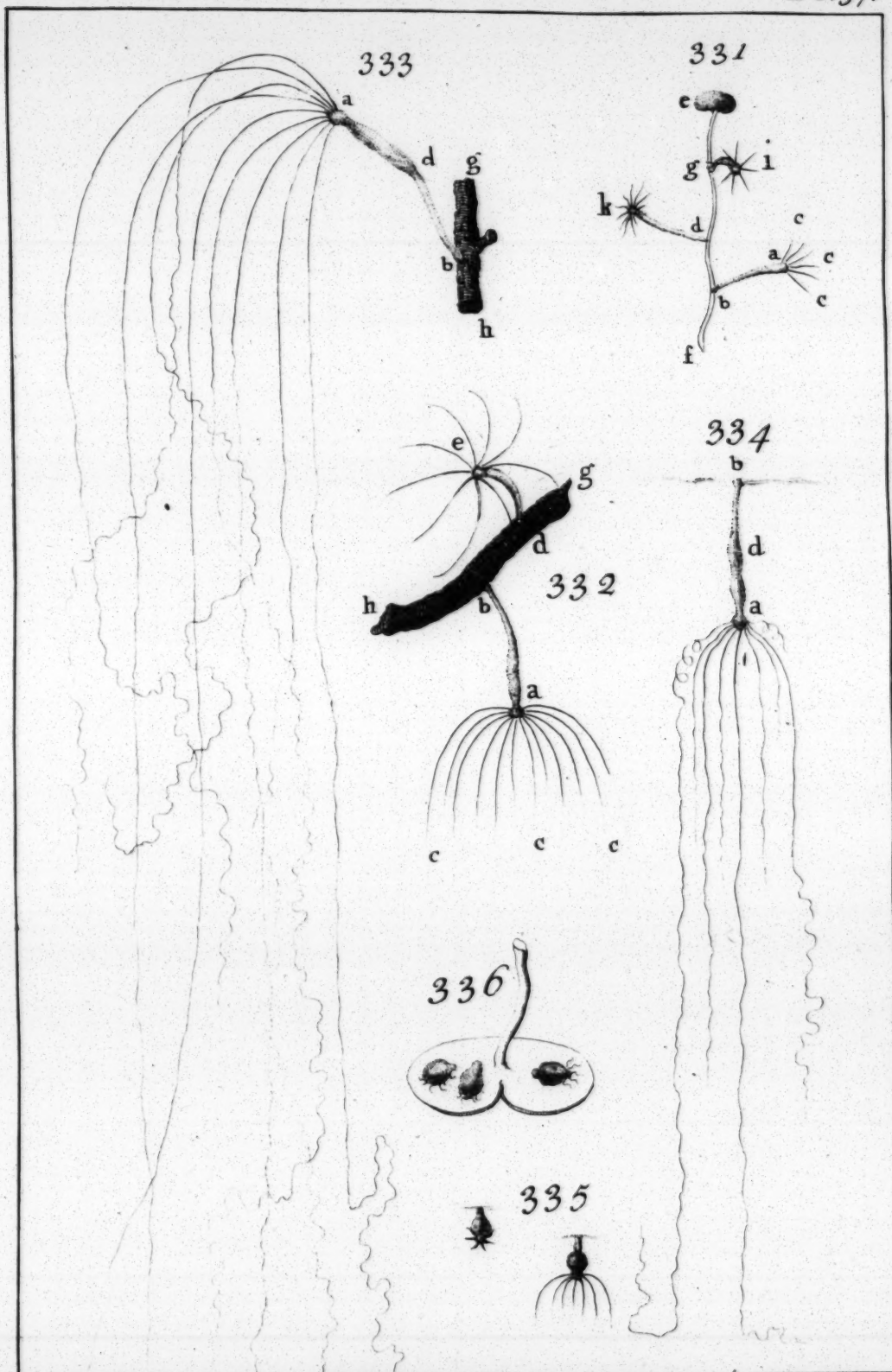
Its Body and Arms are also capable of bending in all possible Directions, some of which are represented by Fig. 337. in which Attitude they are sometimes found; the Body and Arms can also twist themselves, as at Fig. 338, and 334. It is likewise remarkable, that the Arms of the 2d and 3d Sorts of *Polypes*, generally bend at some Distance from their joining to the Body.

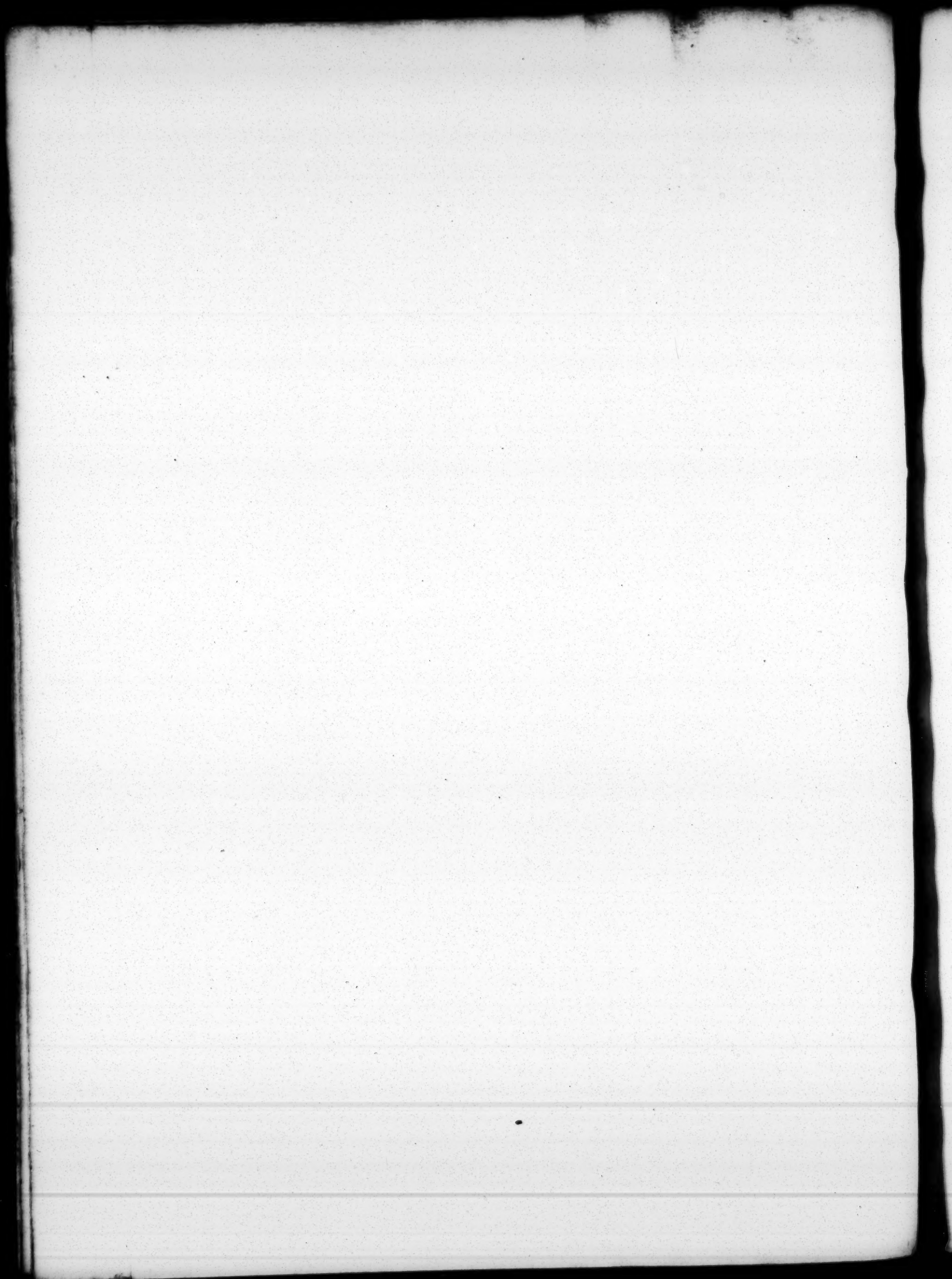
The third Sort, for the most Part, let their Arms hang down, making different Turns and Returns, as at Fig. 333. and sometimes they direct some of them towards the Top of the Water.

Their progressive Motion is performed by Means of that Faculty they have of stretching out, contracting, and turning themselves every Way. For let the *Polype* a b, Fig. 349. be fixed by its posterior End b, having its Body a b, and Arms extended in the Water. In order to advance, it draws itself together, by bending its Body on whatever it moves; and then fixing its anterior End a upon this Body, sometimes the anterior End only, at other Times some of its Arms, and at others the Arms and anterior End a, as at Fig. 350. When the anterior End is well fixed, it loosens the posterior End b, and draws it to the anterior a, fastening the End b, as at Fig. 351. after which it again loosens its anterior End a, and stretches it out, as at Fig. 352. Thus much for a general Description of the common Steps a *Polype* makes in moving from Place to Place.

They walk very slow, and often stop in the Middle of a Step, disposing of, and winding their Body and Arms every Way; as at Fig. 338.

* *Farenheid's Thermometers*, as well as those of Sir *Isaac Newton*, Mr. *Reaumur*, *D'Liſſe*, and others may be had at my Shop, made after the BEST Manner, and graduated myself from actual Experiments; at *Tycho Brahe's Head*, in *Fleet-street*, LONDON.





Sometimes they make an extraordinary Step, as follows, Let the *Polype* a b, Fig. 353. be fixed by its *posterior* End b, and its Body and Arms extended in the Water. First it bends its anterior End a, towards the Body upon which it moves, and fixes it at a, Fig. 354. after which it loosens its *posterior* End b, and raises it up perpendicularly, as at Fig. 355. then bending its Body to the other Side, fixes the *posterior* End b, as at Fig. 356. and loosening the anterior End a, raises it up again, as at Fig. 357.

The third Kind of Step the *Polype* makes, is in the following Manner, let the *Polype* a b, Fig. 358. be fixed by its *posterior* End b against the Side of a Glass. Its Body, and most of its Arms being stretched out forwards, and one of its Arms a c, fixed against the Glass at c: When the *Polype* is in this Attitude, it loosens its *posterior* End b, and contracting its Body, draws it up a little nearer to the Point c, and fixes it against the Glass at d, after which it repeats the same and fixes its *posterior* End at e, and so on. All that is here said of the *Polypes* progressive Motion equally respects the three Sorts.

They descend to the Bottom of the Water, and come up either by the Sides, or upon aquatick Plants, and often hang down from the Surface thereof, by their posterior End, as at b, Fig. 334. and are often seen to suspend themselves by one Arm only, as at c, Fig. 339. They walk as well upon the Superficies of the Water, as upon those Bodies just mentioned; and perform the same Motions in a Glass, as they do in greater Waters: They pass over Plants or other Bodies; they go up the Sides of Glass, even to the Surface of the Water, and pass either under or over it, and sometimes rest themselves there; then they march to the opposite Side of the Glass, and so descend to the Bottom.

If you examine the Extremity of a *Polypes* Tail, while it is suspended, as at b, Fig. 334. (from the Surface of the Water) with a magnifying Glass, it will be found a little out of the Water, somewhat concave and dry, as at b and c, Fig. 359. and to prove that this Circumstance is absolutely necessary to support them at the Superficies of the Water, only wet the dry End with a Drop of Water, and the *Polype* will immediately fall to the Bottom.

When a *Polype* designs to pass from the Sides of a Glass, to the Superficies of the Water, it need only put that Part out of the Water by which it would be supported, and give it Time to dry, which is what it always does, and what may easily be observed. If, for Example, a *Polype* is fixed against the Sides of a Glass, near the Superficies of the Water, (on which it intends to go) as at e f, Fig. 359. in order to convey itself thither, it raises up its *anterior* End, and puts it out of the Water, there letting it dry, then loosening its posterior End f, from the Glass, draws it up, and puts it above the Water, where it also becomes dry in an Instant, and capable to support the *Polype*, upon which it draws its *anterior* End under Water, and remains suspended

from its Surface, as at c and b, often extending its Body and Arms.

It has been often found necessary, in the Course of these Experiments, to suspend a *Polype* from the Surface of the Water, because they are not always to be found suspended there of themselves. To effect which, take in one Hand an Hair-Pencil, and in the other a *pointed Quill*, or a *Tooth-pick*; with the *Pencil* loosen the *Polype* from the *Glass*, and gradually raise it near the Top of the *Water*, in such a Manner, that the *anterior* End of the *Polype* be next the Point of the *Pencil*; then lift it out of the Water, and keep it so for a *Moment*, nay a Minute if you will; after which thrust the Point of the *Pencil*, together with the *anterior* End of the *Polype*, by little and little under the Water, until no more than about half the Tenth of an Inch of the *Polype's Tail* remains above its Surface; at this Instant, with the pointed *Quill*, remove that Part of the *Polype* from the *Pencil*, which is already in the Water. And at the same Time blowing against the *Polype*, its Tail will be also loosen'd, and remain out of the Water.

A *Polype*, that is already suspended, may be removed from a *Glass* of dirty Water, to a clean one with fresh Water, by endeavouring to place the *Pencil* parallel to the *Polype*, and in this Position to advance it gradually till it touches him, he will then apply himself against the *Pencil*, and on being drawn out of the Water, its Tail, which was dry before, will remain so; and it may be immediately put into the clean Water, by observing the foregoing Directions.

Polypes commonly fix their Tails to *Stones*, or *aquatick Plants*, &c. so fast as to prevent their being drove away by the Stream, and are sometimes fixed not only by their Tails, but by two or three of their Arms also, which they direct different Ways; and being thus fixed cannot be tossed about by the Motion of the Water.

Two long armed *Polypes* suspended from the Surface of the Water in a *Glass*, are represented exactly in the Position they were found, at a, b, and c, d, Fig. 359. One of them d c, had two of its Arms d, i, and d, k, fixed against the Bottom of the *Glass*, but on opposite Sides thereof, at i and k. The other a b had also one Arm a g, fixed against the Bottom of the *Glass*, at g, and its other Arm a h, fixed against the Side at h; they held themselves so fast in this Position, that the *Glass* was forcibly shaken before they quitted their Hold.

The *Polype's* Mouth is situated at the anterior End of its Body, in the Middle between the shooting forth of the Arms. It is very often stretched out, at which Time it represents a little conical Nipple, as at a, Fig. 333, and Fig. 343. The Cone it forms appears sometimes truncated, as at a, Fig. 362. At other Times no Nipple can be discovered, the Interval between the Arms being closed, as at a, Fig. 338, and 344. in other Circumstances it is hollow, being open, and a little widen'd, as at i, Fig. 331. or at e, Fig. 332. and a, Fig. 362. it is not only open in this Circumstance,

stance, for if it is observed with a magnifying Glass, when flat, or when it forms a truncated Cone, a little Hole is generally seen at the End thereof, which is represented, as it appears when magnified at a, Fig. 362.

The different Opening of the Mouth and Lips, are seen Fig. 343, 344, and 345.

The *Polype's* Mouth opens into its Stomach, forming a Kind of Bag or Gut, from Head to Tail. The naked Eye may be convinced of this, but much better if it be armed with a Microscope. It is exactly represented as it appears through the Microscope at a b, Fig. 262.

Mr. *Trembley* not being satisfied that the *Polype* was perforated from End to End, by only observing it from without, cut one transversly into three Parts, each Piece immediately contracted itself, and remained very short, and being all three placed on the flat Bottom of a shallow Glass full of Water, and viewed through a Microscope, from the upper End, the Bottom of the Glass was seen through the lower, so that all the three were visibly perforated; they are represented as they appeared in the Microscope, by the Figures 340, 341, and 342. Its Mouth was at the anterior End of one of these Parts a, Fig. 340. and was then wide open. The posterior Extremity was at the End b of the third Part, Fig. 342. as this Piece was perforated thro', it plainly appears, that the Tails of the *Polypes* are also open.

This Perforation which is continued from one End to the other of the *Polype*, is called the Stomach, because it contains and digests the Aliments, and the Skin which incloses the Stomach, and forms this Bag, is the very Skin of the *Polype*. Therefore the whole Animal consists but of one Skin, disposed in the Form of a Tube or Gut, open at both Ends.

If a *Polype* be observed with the Microscope, its whole Body appears like Shagreen, or as if it were strewed with little Grains, as represented at Fig. 362. both when contracted or extended, it is more or less varied according to these or other Circumstances.

If the Lips of a *Polype* be cut transversly and placed upon the Object carrying Glass, in such a Manner as that the cut Part of the Skin a, Fig. 341, may lie directly before the Microscope, it will be found to consist of an infinite Number of those little Grains throughout the whole Thickness of the Skin: Therefore, in order to know whether the Inside of the Stomach had any of the like Grains; Mr. *Trembley* opened several of them in the following Manner; by putting a *Polype* upon his Hand, he made it, by touching, to contract as much as possible, and then he introduced a very fine Point of a Pair of Scissars into its Mouth, and forcing it out at the Tail, and immediately closed the Scissars, which cut one Side of the *Polype's* Skin from the Top to the Bottom, and laying it open from one End to the other discovered the interior Superficies thereof, which is represented as it appeared in the Microscope at Fig. 346; and this was also composed of as

great a Quantity of the same Grains as the exterior Superficies and the Edge a, of the cut Piece of Skin, Fig. 346. To examine these Particulars a little farther, a Bit of the Skin was laid upon the Object carrying Glass in a Drop of Water, and placed before the Microscope, a, Fig. 347. and some of these Grains separated therefrom, as at b, c, d, by pressing them with the Point of a Pin, striking them against the Glass, and endeavouring to tear them in Pieces; the Grains spread themselves to all Parts of the Water, and at last remained in Heaps as at e and f.

If a *Polype* be carefully placed before the Microscope, so as not to wound him, you'll seldom be disappointed of seeing those Grains separate from some Part or other, and that in the most healthy *Polypes*; but when they separate in large Quantities, it is a certain Symptom of a dangerous Illness. The Surface of the *Polype* from which they fall becomes irregular, and is no more terminated as before. The Grains fall off from all Sides, it contracts itself, the Body and Arms swell and lose their shining Whiteness, and at last their Form, as at a, Fig. 348, and nothing is to be found in its Place but an Heap of Grains as at b.

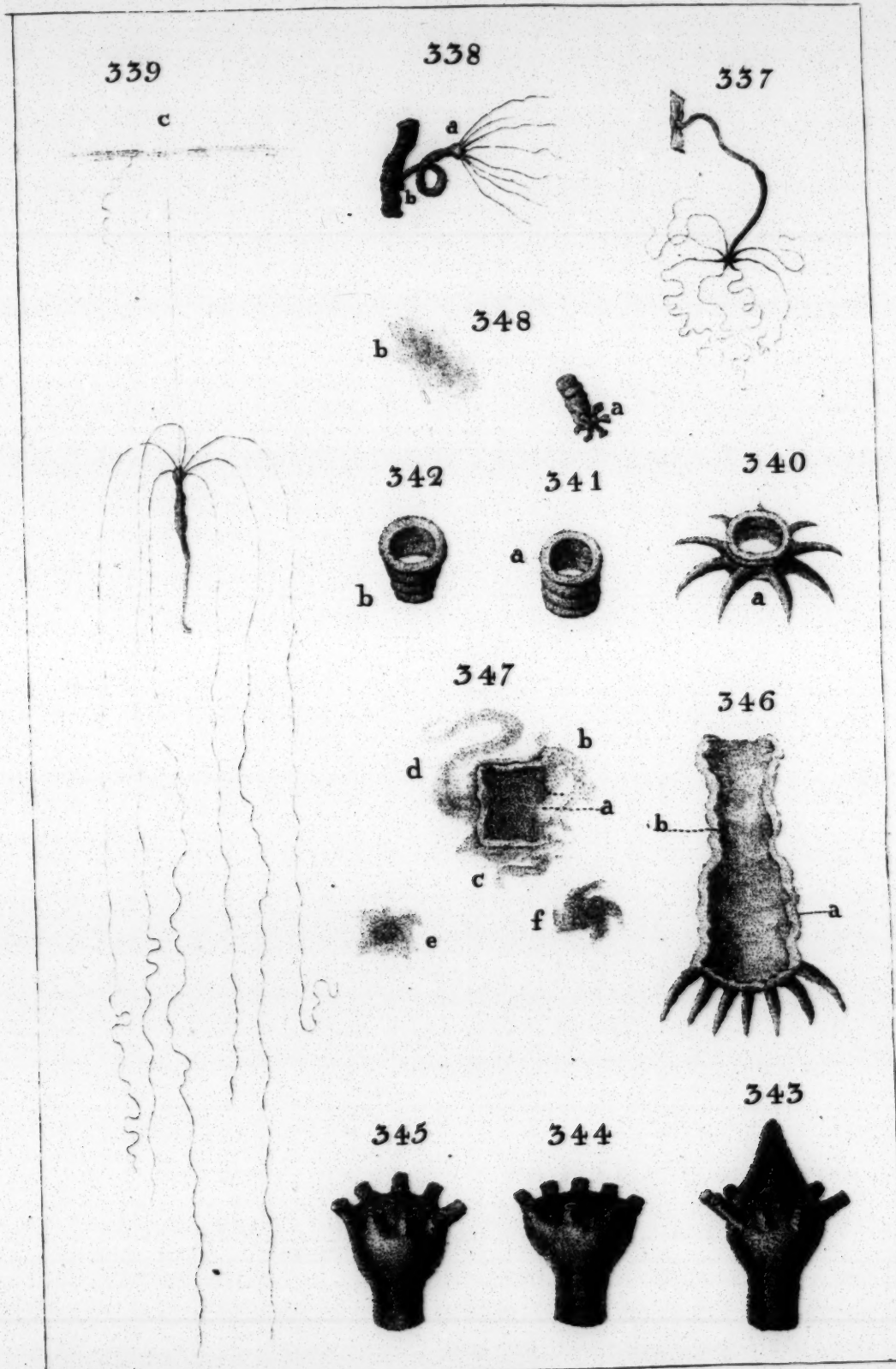
The Structure of the *Polypes* Arms bears a near Resemblance to that of its Body; and when observed with the Microscope, we find their exterior Surface to appear shagreened also, Fig. 362, an Arm much contracted appears extremely so, and even much more so than the *Polype's* Body.

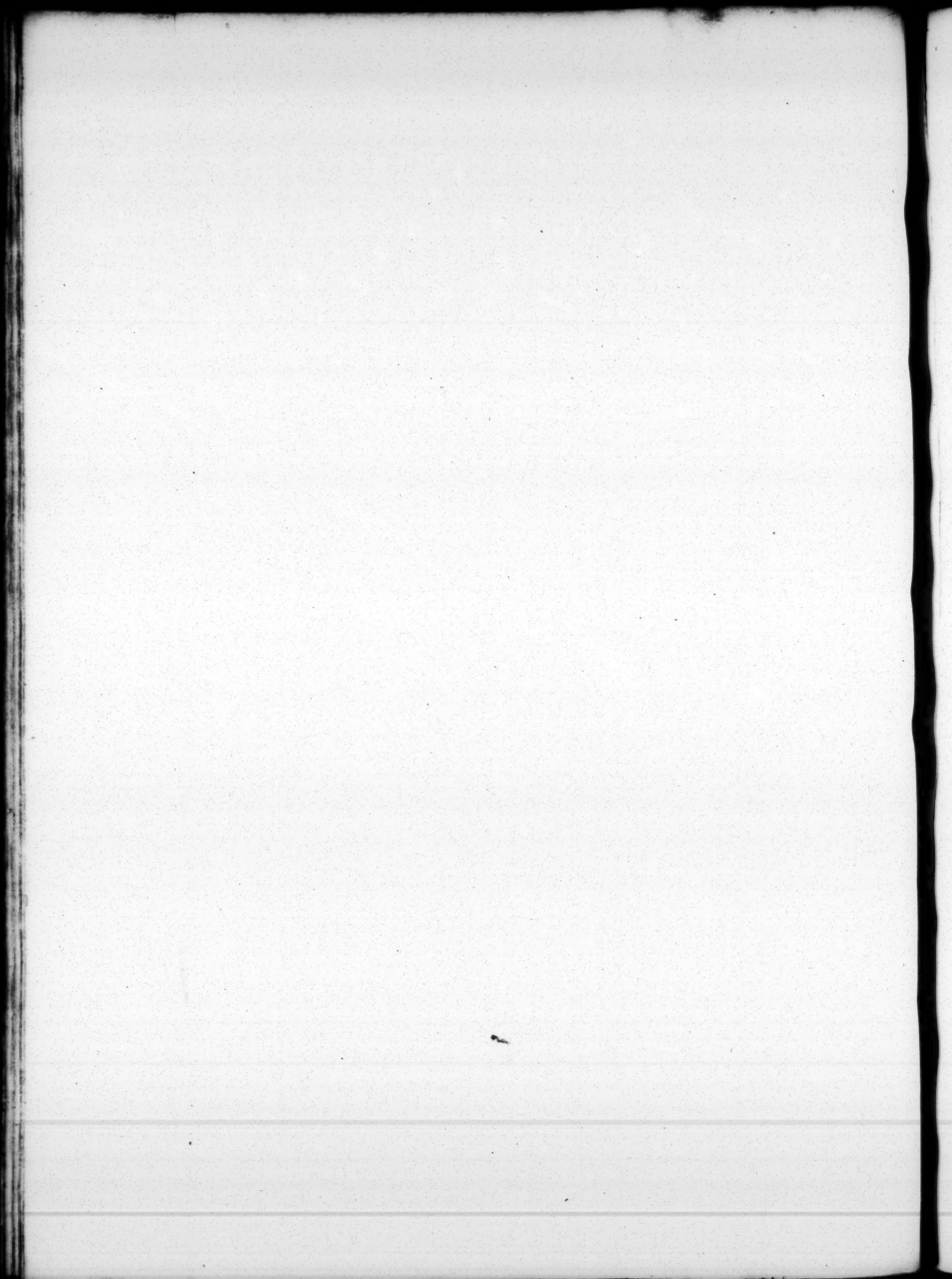
If a suspended Arm that extends itself be observed, the Grains may be seen a little asunder, which when contracted almost touch, but so that Intervals are left between them, as at Fig. 363. When at a certain Degree of Extension, its Surface seems only to be strewed with Pimples as at Fig. 364, which continue still to separate, as the Arms extend, and are at last placed upon a Thread e e e, Fig. 365. These Pimples are formed by the Re-union of many Grains, and at the first Glance appear like a String of Beads, Fig. 365.

The different States of a *Polype's* Arm, may be observed at the same Time, in the same Arm, but at different Places thereof, by casting the Eye, armed with a Microscope from one End of the Arm to the other, and especially if the several Portions thereof be carefully observed with a large Magnifier, they will appear as at Fig. 363. which represents that Part of the Arm stretched out, which is near the *Polype's* Head, the Grains thereof being but little separated, but are farther asunder in Fig. 364. which is about the Middle of the Arm; and Fig. 365. shews the Grains as if they were strung upon a Thread, as they are seen upon the Extremity of a *Polype's* Arm.

This Extremity is often terminated by a Knob, and the Hairs marked e, e, e, Fig. 364, 365. are transparent, and may be seen with the first and second Magnifiers.

The





The best Method to observe a *Polype's* Arm, is to choose one that is fixed to the Side of a Glass, and near the Superficies of the Water; at which Moment, any one of its Arms being very well extended, take a Pair of Nippers in one Hand, and a Slip of Glass, about two or three Inches long, and half an Inch broad in the other, holding it at one End between the Finger and Thumb; then with the Nippers, or a pointed Quill, pull the End of the Arm gently out of the Water, and the rest will follow. If it is not stretched enough, stretch it more, by drawing it out, the *Polype* still remaining fixed to the Glass, put the Arm upon the Slip of Glass, and turn it under till it meets itself again; then giving it a Jirk, the Arm will break off on both Sides the Slip of Glass, one Part remaining with the *Polype*, and the other in the Forceps, and the middle Part will stick upon the Glass Slip, in which Manner it may be applied to the Microscope, and preserved for several Days, as well as when it is at first taken out of the Water, for when once dry it does not change for a considerable Time.

S E C T. II.

Of the Polypes Food, and Manner of their seizing upon, and swallowing their Prey.

IT was some Time after the Discovery of the second Sort of *Polypes*, before Mr. *Trembley* could find out a proper Food to nourish them, but the Water at that Time happen'd to be plentifully stored with a Sort of Millepedes, Fig. 360. small enough, and about $\frac{3}{4}$ ths of an Inch in Length. They are remarkable for a Horn, or fleshy Dart, proceeding from the fore Part of their Head at d. Mr. *Reaumeur* hath called them darted Millepedes. They support themselves, and swim in the Water by Means of the several swift Inflections they make with their Bodies; they rest themselves, and creep upon all the Bodies they meet with, and are often found in great Numbers upon aquatick Plants, those upon which the first *Polypes* of the second Sort were found, were well stocked with these Millepedes, and were taken out of the Water together with them, and put into the same Glass without any Design.

A few Days after the anterior End a, of a *Polype*, Fig. 366. was observed, with one of these Millepedes partly within its Mouth, and the other Part yet without it at m, not knowing at first whether the *Polype* was eating the Millepedes, or whether the Millepedes had introduced itself voluntarily into the *Polype's* Stomach, to be nourished there, to lodge its Eggs, or deposite its Young therein, but at last it was entirely enter'd into the *Polype's* Body.

The long arm'd *Polypes* being the most remarkable in their feeding, &c.

for that Reason principally, Mr. *Trembley* thought proper to describe these Experiments, upon that Sort, from which one may easily judge the same of the other two Sorts.

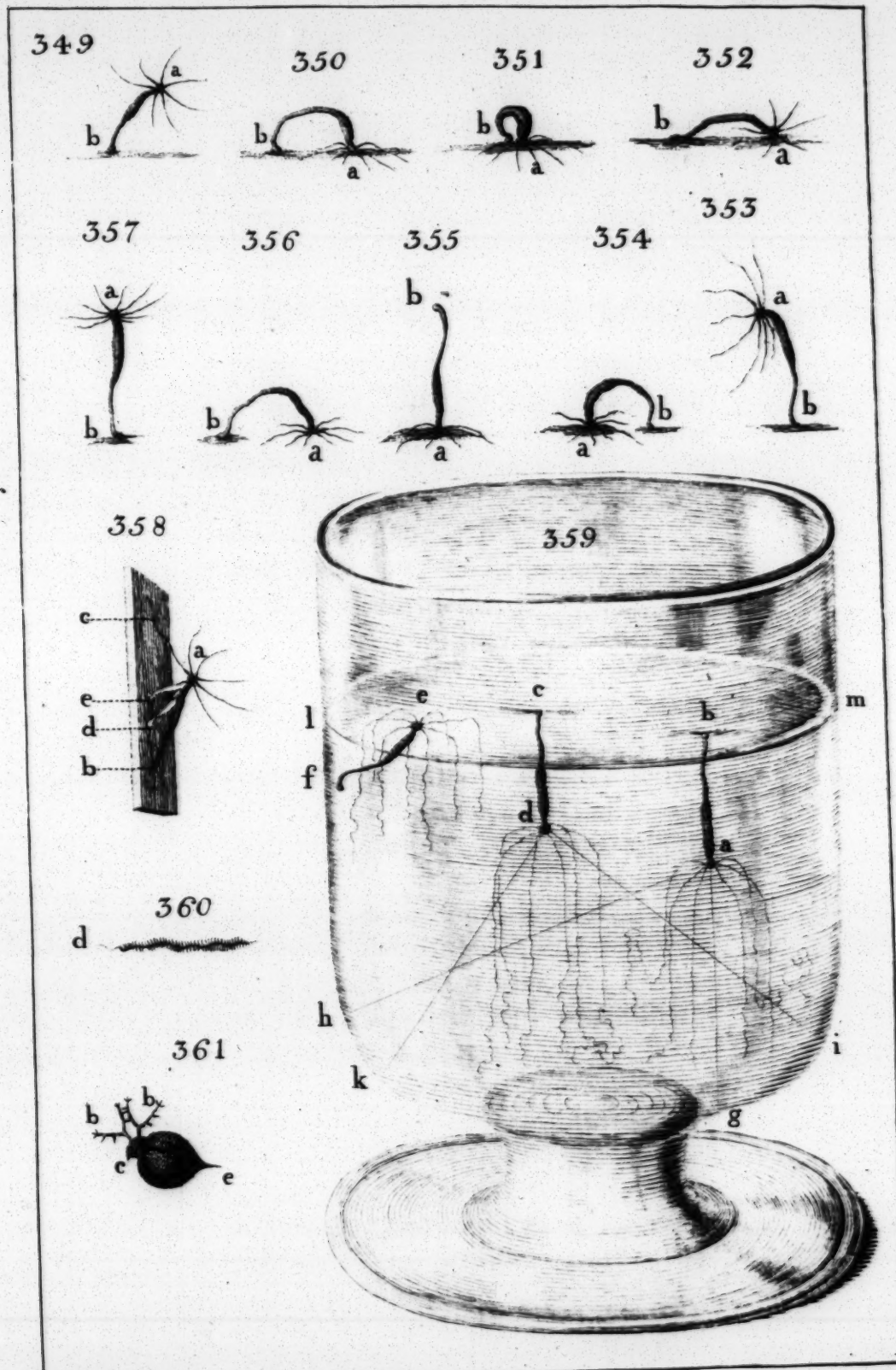
To see these Polypes seize their Prey with their Arms extended, they must be put into a Glass, 7 or 8 Inches deep, if the Polypes are fixed to the Top of the Glass, their Arms for the most Part hang down towards the Bottom. This is then the most convenient Situation to give them Food, and to observe how they manage it. To this End one might cause them to hang from the Surface of the Water, but this Expedient is not always best.

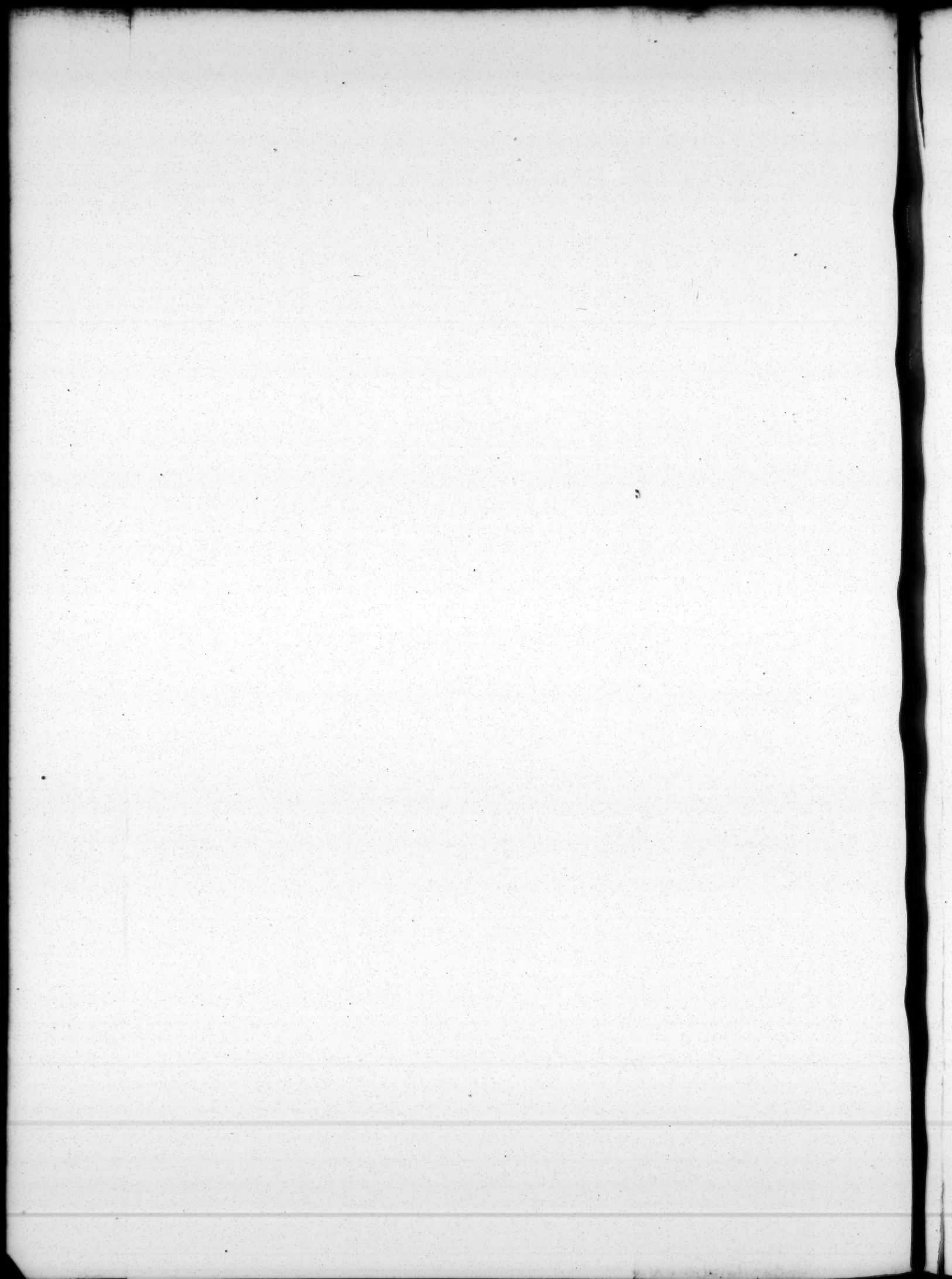
The Polypes we breed, and feed, are commonly infested with little Lice, it is therefore necessary to cleanse them from these Tormentors, by rubbing them with an Hair Pencil, and if the Polypes suspend themselves from the Surface of the Water, it is scarce possible for them to be freed from these Lice. In that Case make the Polypes fix themselves to a Packthread, or fix them to it, as at Fig. 367. at the Place b, letting the two Ends h f, and k g hang down over the Edges of the Glass. One may then stroke them even something rudely, backwards and forwards, with an Hair Pencil, without pulling them off, and in changing the Water, only take hold of each End of the Pack-thread, draw it gently out of the Water, and put it immediately into another Glass, prepared for its Reception. If several of these Pack-thread Strings are put into a Glass well stored with Polypes, there will be always some that will fix * themselves thereto.

When the Arms of the Polype are well extended, put a Millipedes, or any other Worm into the Glass, and with the Point of a Pencil, push it to one of the Arms, which it no sooner touches, but it is seized, and when the Millipedes m, c, n, or Worm perceives itself taken, it endeavours by very quick and strong Efforts to disengage itself, often swimming and dragging the Arm a c, Fig. 367. from one Side of the Glass to the other; this violent Motion of the Millipedes, obliges the Polype to contract its Arm, in the Performance of which he often disposes them in the Form of a Cork-screw, o i, which also contributes to the shortening of it. The Millipedes by its continual Struggles, entangles itself in the Arm that holds it, m i n, and often meeting with other Arms, they also assist, and with a sudden Pull, enable the Polype to contract himself, or to draw near his Prey, and in an Instant the entangled Millipedes is convey'd to the Mouth, against which it is held and subdued.

When a Polype hath nothing to eat, its Mouth is generally open, but that so small that it cannot be seen without the Assistance of a magnifying Glass: Whereas, as soon as the Arms have conveyed a Prey to the Mouth, it opens itself more, and always in Proportion to the Size of the Animal

* *Hist. de Polyp. p. 85.*





that is to be devoured ; its Lips gradually dilate, and precisely adjust themselves, to the Figure of their Prey.

All the Worms which are seized by the Polypes, do not present themselves in the same Manner to their Mouth ; for if the Worm presents itself by one of its Extremities, it is not requisite the Polype should open its Mouth considerably, neither does it open otherwise, but precisely to give Entrance to the Worm, Fig. 366.

If the Worm is not too long for the Stomach, it remains therein extended ; but if longer, that End which first entered bends, and when it is entirely swallowed it may be seen folded within the Polype, Fig. 379.

When the Middle or any other Part of the Worm is presented to the Polypes Mouth, it seizes this Part with its Lips, extending them on both Sides, and applying them against the Worm ; at which Time its Mouth takes the Form of a Boat pointed at each End, Fig. 368, after which the Polype gradually closes the two Points of its Boat-like Lips, which doubles the Worm in that Part, and so it is swallowed, Fig. 369.

As soon as the Stomach is filled, its Capacity and the Skin thereof is augmented, and the Body becomes short, Fig. 372. its Arms also are for the most part contracted. The Polype hangs down without Motion, and appears to be in a State of Numbness, and in Shape very different from that of its Extension, Fig. 367. As the Food digests, and it voids that which does not serve for Nourishment ; its Body lengthens, and gradually recovers its natural Form.

Mr. *Trembley* finding these Millepedes a proper Food for the Polypes, he collected a great Quantity of them, to feed those he kept in Glasses, and found them in Swarms at the Sides of Ditches, creeping on Plants, and all other Bodies that were in the Water.

Also on observing how voraciously the Polypes eat these Millipedes, he imagined it was not the only agreeable Food to them, and was therefore desirous of finding out other Animals to nourish them withal, besides the Trouble of getting a sufficient Quantity of Millipedes from other Places took up too much Time ; upon which he opened a Polype that was taken out of the Water, with its Belly full of Food ; from whence came out little Insects, which he calls *Pucerons* or *Fleas*, and amongst these another Sort that multiply extremely, and are often easily to be procured in great Quantities ; see the Fig. marked p, at the End of one of the Arms, Fig. 367, which represents one of these Fleas of its natural Size, and as it appeared in the Microscope at Fig. 361 : They are exactly described by *Swammerdam*, * and are remarkable for two branching Arms, which proceed from their Head, which serve them instead of Fins. The Arms inclined *Swam-*

* *Swam. Hist. de Insect. p. 86. 3^e Edit. de Leid. 1737.*

merdam to call them by the Name of *Puceron branchus*, they are continually skipping about the Water, and are generally somewhat reddish.

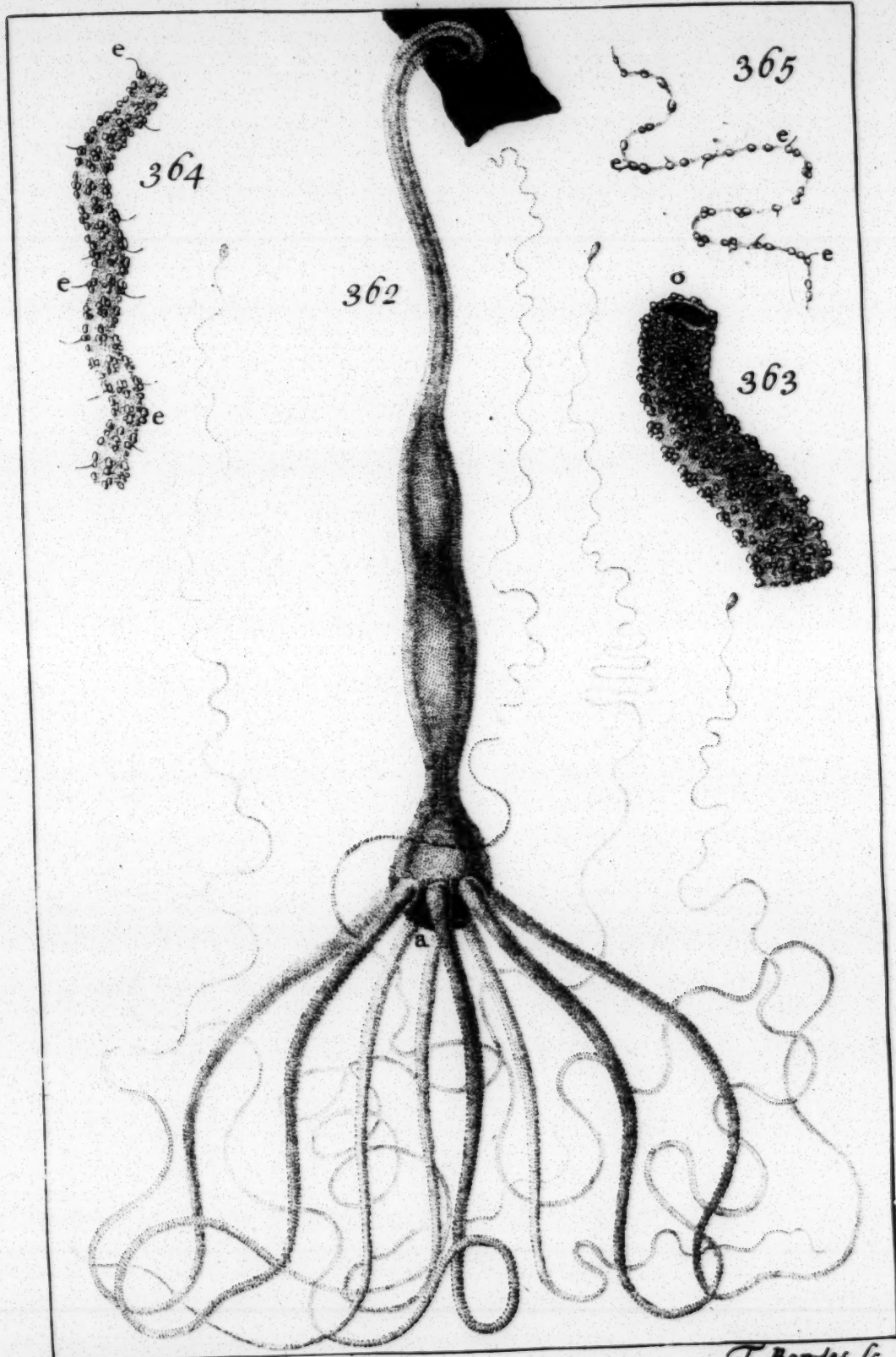
On putting some of these *Pucerons* into a Glass with Polypes, they presently seized on some of them, and began to extend their Mouths, first in the Form of a Concave, in which Part of the *Flea* is lodged, as at a, Fig. 370. the Lips continue to enlarge, till they included the *Puceron*, and then entirely close themselves again.

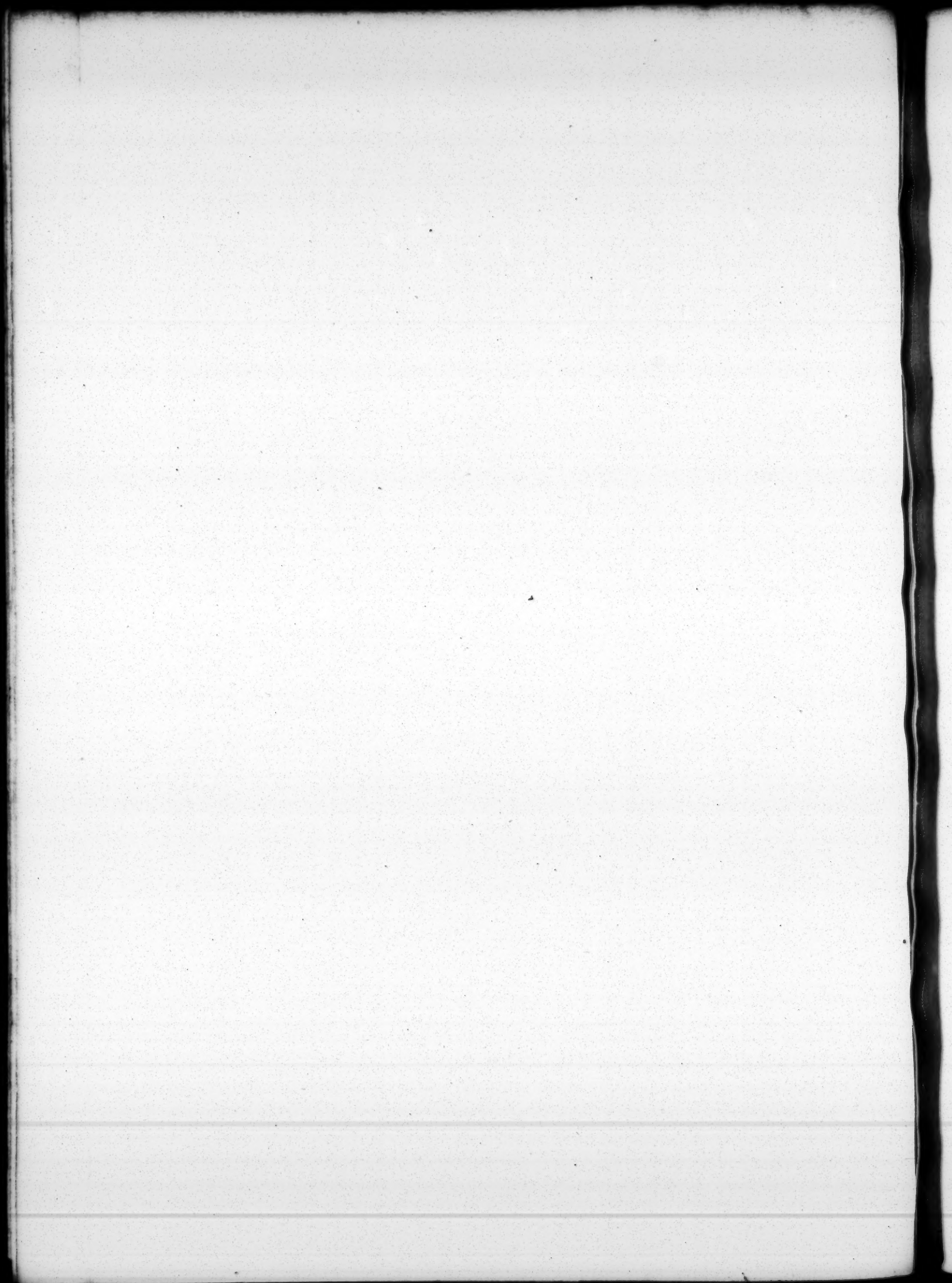
The Polypes are not content with two or three of these *Pucerons*, but will continue to swallow them till the Sides of their Stomach are so increased, as to contain two of these *Fleas* in Breadth one by the Side of the other, as at Fig. 371. which was absolutely full from Head to Tail. If it be one of the third Sort, the narrow Part of its Body b d, Fig. 372. generally remains empty, but sometimes this also is forced to increase and receive some of those *Fleas*. When the Polype hath swallowed no more of these *Fleas* than can be contained within its Stomach; its Body, in that Case, becomes very small near the Head, and forms in that Place a Kind of remarkable Neck c, Fig. 373.

If a Number of these little *Fleas* be hastily thrown into a Glass of hungry Polypes, their Arms are soon so loaded with them, that one can see nothing but a confused Mass of these *Pucerons* gathered together, near the Polype's Mouth a, Fig. 375. which they swallow one after another till they are entirely full.

So long as these *Pucerons* could be procured, he fed his Polypes with nothing else: His Method of fishing them out of the Water, was with a small Hoop, of about 8 or 10 Inches Diameter, made of Brass, or Iron Wire, to which was fastened a Pouch of Linen Cloth, and the whole tied to the End of a Stick. This being put slope-wise into the Water, where there is a Quantity of these Animals, may be easily moved to and fro, any Way you see Occasion, by which Means the *Fleas* will be gathered together into the Hoop. You may then put them into a Glass of Water, which will swarm therewith from the Beginning of *June* to the End of *September*; these were easily to be procured, but when they began to fail, he was at a Loss to find out other Nourishment for his Polypes.

He went several times a Day to the Water-side, which had before for a long Time furnished him with *Fleas*, and stooped down near the Surface of the Water, endeavouring to discover young ones, but all in vain; nevertheless in seeking these he saw several Places at the Bottom of the Water, with Worms all standing an End, one End of which was in the Earth, and the other End out of the Earth in the Water, making continual Undulations, Fig. 376. He thought, as soon as he saw these Worms, they would serve to nourish the Polypes, and to make up for the *Fleas* he wanted, and the Millepedes which could at that Time be found only in small Quantities; it was with a great deal of Trouble that he took up some of those





Worms, which he gave to the Polypes who eat them. Therefore, to procure as many of these Worms as you may have occasion for, you need only fix a Circle of Iron Wire, two or three Inches Diameter, to the End of a Stick, and putting this into the Water, and about half of it under the Earth, run it along a little Way, always holding it in the same Position, and that a little inclin'd; this will meet the Worms, and drag them along with it, and bring up a large Quantity thereof, which on shaking the Wire Circle in a Glass of Water, will all fall to the Bottom. If the Ditches where you fish for these Worms should be cover'd with Leaves and Herbs, it is necessary first to cleanse them with a Rake, before you put in the Iron Circle, otherwise you'll get but few Worms at a Time. There are also other Places so muddy, as to hinder the Wire from holding the Worms; in this Case it is expedient, that you throw upon the Mud some Inches of Sand, for as the Worms are obliged to keep Part of their Bodies above the Superficies of the Earth, they quit the Dirt, and pass into the Sand, and remain near the Superficies thereof. They may be taken in very great Quantities, after preparing the Bottom of the Water in this Manner.

These Worms are found in great Abundance in the Mud of the River *Thames*; when the Tide is out, they rise in such Swarms on the Surface thereof, that it appears of a red Colour.

You may give to each Polype a Worm much longer, and also a little thicker than the Polype is when extended; but then Care must be taken to let the Worm fall upon their Arms, otherwise they will miss of them, because they fall directly to the Bottom. Their Sense of Feeling is so delicate, that if a Worm touches even the utmost Extremity of these very slender Arms, they immediately by clasping them about it, envelope and fetter it in so many Places, that it is soon render'd incapable of struggling to any Purpose, it easily yields, and at last is swallowed into the Polype's Stomach, Fig. 380. where it may be discern'd thro' the Polype's Skin.

These Worms are the best Nourishment for the Polypes, especially in the Winter, therefore if you gather a sufficient Quantity of them in *November*, and put them into large Glasses full of Water, with three or four Inches of Earth at the Bottom, you will have a Supply for the Polypes all the Winter, and may fish them up out of these Glasses, as out of the River.

Sometimes a pretty thick red Worm, about half an Inch long, is taken up with the rest, and is represented at c d, Fig. 382. It is the same as that described by Mr. *Reaumer*, in the *First Memoir of the 5th Tome of his History of Insects*. Page 29.

Polypes may also be nourished by these Worms, but they are more difficult for them to digest, and not at all fit Food for them in Winter.

Mr. *Trembley* hath also seen them eat a Worm, which he calls a transparent

rent *Tipula*, of which Mr. *Reaumer* speaks in the 40th Page of the Memoir just cited.

Having in the Month of *June* taken a great Quantity of little Fish, about four Tenths of an Inch long, and given some of them to the Polypes, but the extreme Vivacity of this Fish, was almost too much for them to encounter with; however, all the Polypes that seized them, did swallow them, and the Tails of the long armed Sort were obliged to stretch open to receive the Fish: One of the second Sort is represented at Fig. 377. which had swallowed one of these little Fish; and as its Skin *a b*, was so transparent, and flexible, it took the Form thereof, and appear'd like a Fish with long Whiskers.

The *Polypes* eat the major Part of those little Insects that are found in fresh Water, they are very well nourished with *Worms*, and the *Nymphs* of *Gnats*, and other *Flies*; they will also eat larger Animals if they are cut into little Pieces, as *Snails*, and other larger *aquatick Insects*, and *Earth Worms*, the Entrails of *Fresh-Water Fish*, and *Butcher's Meat*, as *Mutton*, *Beef*, and *Veal*.

Mr. *Trembley* put into the Bottom of a Vessel, some of the Earth taken out of a Ditch, imagining, that a great Number of little Insects might be lodged therein, or at least the Eggs of some; which Experiment succeeded very well, for from the End of *February* 1742. it was stored with various Sorts of little Animals; but particularly with one Sort, which is inclosed in a two-fold Shell; when this Shell was but a little opened, they put forth several minute Feet or Arms, that move exceeding quick, and by Means of this Motion they swim. These Animals place themselves upon all Bodies they meet with, and are about the Bigness of a Grain of Sand; some Polypes being put into this Vessel, without taking any other Care of them, were nourished therein, and multiplied for eight Months.

Whence it appears, that large Glasses or Pails, thus prepared with Earth, (at the Bottom of them) taken out of Ditches in the Summer-Time, will be a convenient Residence for the Polypes; for besides those Insect Eggs that are contain'd in this Earth, may be very often seen (especially if the Water in the Glass be exposed to the Air) the Spawn and Nymphs of *Gnats*, and of *Tupula*, or *Water-Spiders*, &c. These Vessels may then be successfully employed, and will save the Trouble of feeding the Polypes we intend to preserve, and also of often changing the Water. But when it is not changed and cleansed for some Time, it is generally filled with an Herb, as fine as Hairs, in which the Polypes entangle themselves, and by which we are hinder'd from looking within-side, if the Vessel be not made of Glass; however this Inconveniency is prevented by putting into each Vessel a few *aquatick Snails*, more or less in Proportion to its Size; they will eat these Plants as fast as they grow, whereby the Water, and the Sides of the Vessel, will always remain clean.

Some-

Sometimes two Polypes seize the same Worm, and each begins to swallow its own End of the Worm, continuing to do so till their Mouths meet, Fig. 378. In this Posture they remain for some Time, after which the Worm breaks, and each Polype hath its Share; but at other Times the Battle does not end there, for each of them continuing to dispute the Prey, one of the Polypes opens its Mouth advantageously, and attempts to *swallow* the other Polype with its Portion of the *Worm*, which he effects in some Degree, and sometimes almost entirely as at Fig. 380. Nevertheless this Combat ends more happily than we can at first believe, in Behalf of the devoured Polype; for the other gets the Prey entirely out of its Stomach, and the devour'd one comes forth again sound and safe from the Body of its Enemy, after having been detain'd there above an Hour.

Polypes can eat a great deal at a Time, and they can fast a great while; and they void their Excrements at their Mouth.

After a Worm is swallowed, the Transparency of the Polype's Skin will permit us to see it distinctly, as at Fig. 379. the Worm gradually loses its Form, and is at first macerated in the Stomach of the Polype, the Juice nourishes, and being separated, the Remains thereof are thrown out at the Mouth, as at Fig. 381.

It is also observable, that their Aliments are pushed backwards and forwards, from one Extremity of the Stomach to the other, which contributes much to its Digestion; which Motion may be seen in the Microscope, if you choose a Polype that is not too full. This Kind of peristaltick Motion spreads the nourishing Juice all over the Stomach. But for an Observation of this Kind, it is best to feed the Polypes with such *Aliments* as can bestow a *lively colour'd Juice*; for Example, those *Worms* whose Intestines are full of a *red Matter*, for by this Means we may see, that this alimantal Moisture is conveyed not only to the Extremity of the Body, but also into its Arms; whence it is plain, that a Polype's Arms are perforated, each of them forming a Kind of Gut, which communicates with that of the Body.

This was confirmed by examining a Polype, which had sucked the red Matter contained in the Intestines of a flat Worm, Fig. 383. Its Body is of a transparent White, and Intestines extreamly visible, and of a crimson Red; Care must be taken to choose those which are of a proper Size for the Polypes to swallow; they come out of the Polype's Body without being macerated, the red Matter which was in their Intestines being only extracted from them.

But this Experiment was yet better confirm'd on giving a Polype some Bits of the Skin of a little *black, flat Snail*, to be met with in great Abundance in *Ditches*. The Matter of this Skin was soon reduced in the Polype's Stomach to a Kind of Pap, principally composed of little black Fragments, and on examining their Motion attentively with the Microscope, were seen to be drove about in their Stomach, and to pass from Head to Tail,

and into their Arms, even to a Thread; and afterwards were sent back in to the Stomach, and chased from thence to the Extremity of the Tail, and were again repelled from thence towards its Mouth, and into the Arms, and so on continually.

These Experiments were several Times repeated, and succeeded in the same Manner.

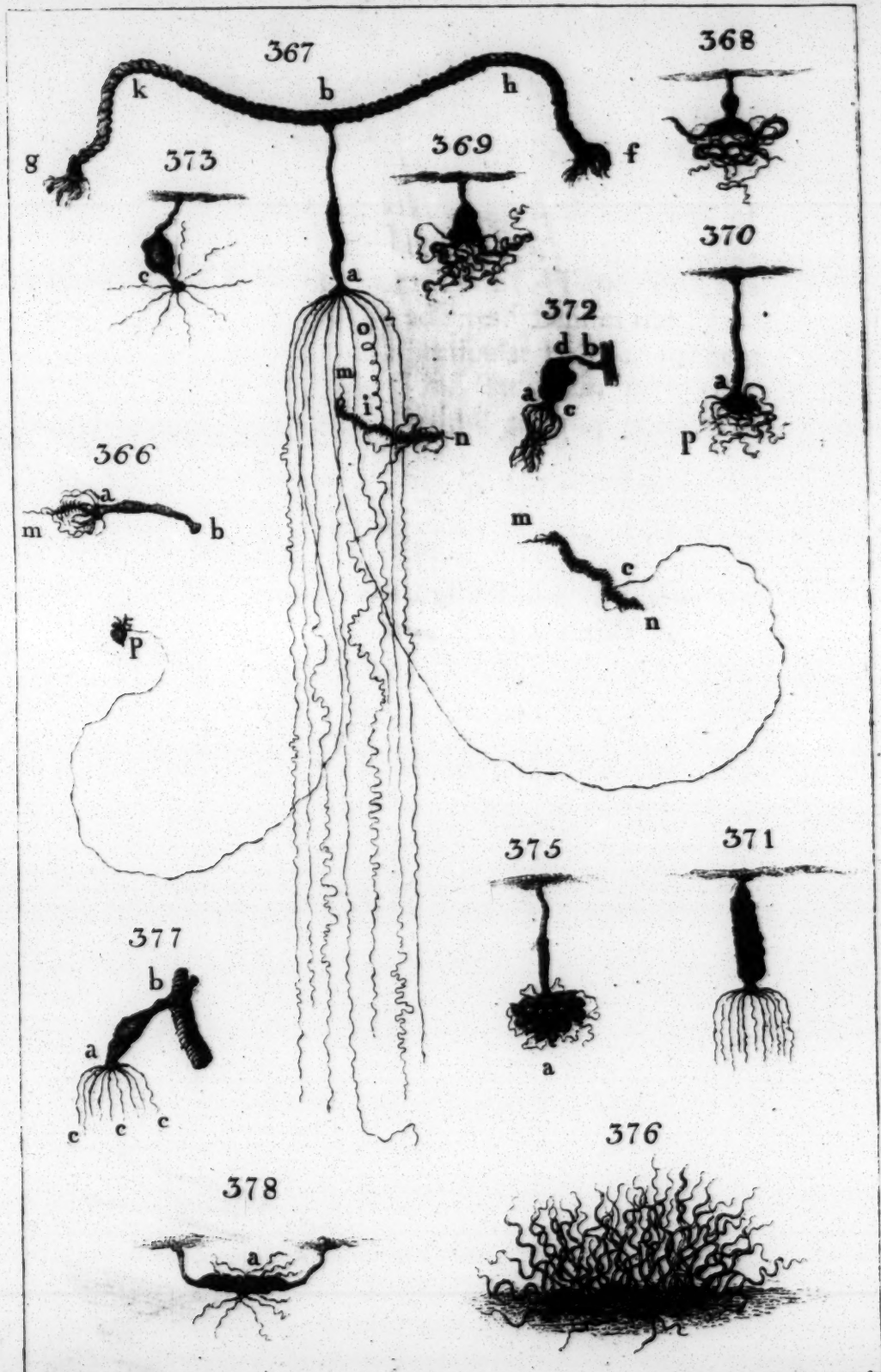
They are also a Proof of the Polype's Arms being tubular, and that they have an open Communication with the Stomach.

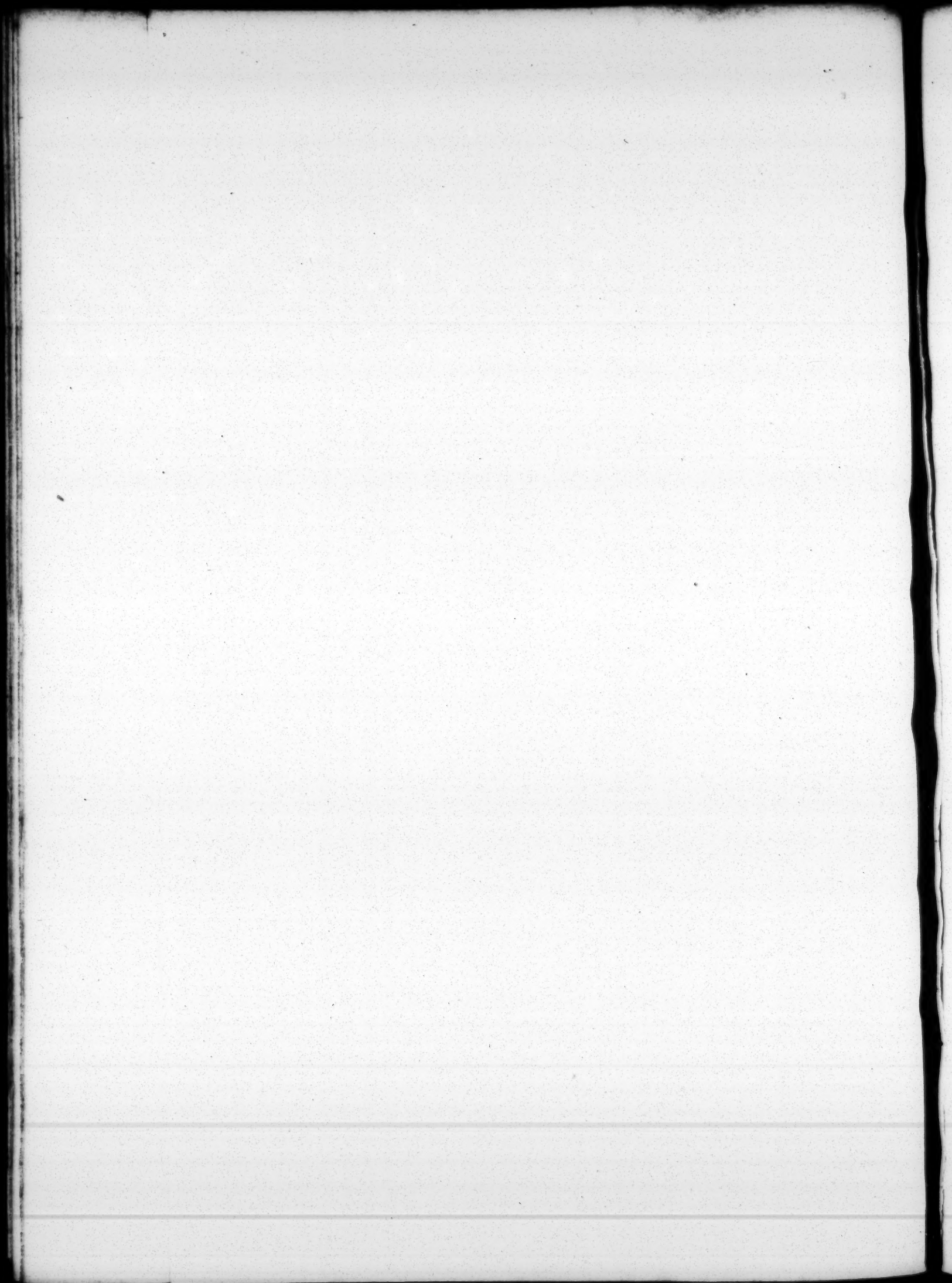
The Arms of the Polype are of the same Colour with its Body, and an Heap of the extravasated Grains before spoken of, are of the same Colour also; it is therefore evident that the Colour of the Polype depends on the Colour of those Grains which compose the Skin, (for when the Polype becomes white, they lose those Grains) and their Dependance is upon the nutritive Juice, drawn from the Aliments.

These Grains, for Example, become red or black, if the Polype be fed with a red or black Juice; they are more or less tinged with these different Colours, in Proportion to the Strength and Quantity of the nutritive Juice. It is also observable, that they lose their Colour, if not fed with Aliments of the same Colour to themselves, and likewise that they will fast a great while, but then they waste proportionably to their fasting.

They are also subject to be infested with a Kind of aquatick Lice before spoken of, which are very common in exposed Waters; they are of an oval Figure, and generally white; they run very swift upon the Polype's Body, and crowd about its Head more than any other Part, as at Fig. 385. Nevertheless they may be seen in great Numbers running over the Body *a b*, and Arms *a c c*. The present Figure is a Representation of the Polype and Lice, as they appear in the Microscope. If proper Care is not taken to keep them clean from these Animals, they will be devoured by them, their Arms will gradually diminish, and at last their Body, till there is nothing left. Fig. 386. represents one that had all its Head Part eat up, which after having been cleansed, had a new Head, and new Arms, and became a very fine Polype.

Therefore the best Way to preserve these Animals in Health, is often to change the Water, and that especially after they have done eating. It is not enough to pour it off, but they must all be taken out, and the Bottom and Sides of the Vessel rubb'd clean from the slimy Sediment adhering thereto, which is caused by the Fæces they disgorge therein, which are converted into a Kind of Slime, fatal to them if not clear'd away. My Way is to loosen their Tails from the Sides or Bottom of the Glass, then I take them up one by one with a Quill, cut Scoop-fashion, and place them in another Glass with clean Water; sometimes they cling to the Quill in such a Manner, as not easily to be disengaged. The only Way then is to let the Quill remain a Minute or two in the Water, till they discharge themselves,





selves, otherwise you'll be in Danger of breaking their Arms off, however when an Arm is broke, it is quickly repair'd again, but for some Days there appears a Swelling or Callosity in the Place which wears off in Time.

River, or any other very soft Water, agrees best with them, or what is taken up clear, out of some Ditch or Pond; but that which comes from a Spring or Pump, or is in its own Nature hard or sharp, prevents their thriving, and kills them in a few Days.

They are best kept in such large Glasses as hold three or four Quarts of Water, for in a Glass of this Size, the Water need not be renewed so frequently, especially if the Fæces are taken out from Time to Time, with the feather'd End of a Pen, to which it very readily adheres. Besides the Trouble is in some Measure saved of feeding each particular Polype, for here you need only throw in a Parcel of Worms, and let them take their Chance, but then all of them are not constantly fed, nor any of them so often as in the smaller Glasses.

The Worms you feed them with, must also be well cleansed from the Mud, and always remember to wash them in clean Water, every Time you feed the Polypes therewith.

Polypes are to be sought for in the By-Corners of *Ditches*, *Puddles*, and *Ponds*; for it is observable, that the Wind drives them together with the Plants, upon which they float into these Places; although we may search for them in some Places without Success, yet on coming there again, they may perhaps be found in great Abundance.

There are fewer of them in the Waters in Winter, than in the other Seasons. About the Month of *April*, *Duck-Weed* begins to rise above the Superficies of the Water, and to increase, and many other Plants also float upon the Water, the Warmth revives the Polypes, and they fix themselves to these Plants in Quest of Prey, at which Time they may be taken out of the Water with them.

S E C T. III.

Of the Generation of Polypes.

WHEN a young Polype first begins to shoot, there only appears an Excrecence, which terminates in a Point e, Fig. 387.

Some Time after that, when it appears cylindrical, its Arms also begin to shoot at its anterior End, c, i, Fig. 387. Its posterior End is fixed to the Body of its Mother, and gradually grows narrower, till at last it only appears to adhere thereto by a Point b, Fig. 388. at which Time it is ready to be separated; which they all perform in the same Manner. The Mo-

ther and young one fix themselves to the Glass, or other Bodies upon which they are situated, with their Arms and Head, and this is their Preparative for a Separation; sometimes the Mother gives a Twitch, at other Times the young one, and often both together.

A Polype a b, Fig. 389, with a young one c d, ready to be separated, disposes of its Body in an Arch of a Circle, a, b, d, against the Sides of the Glass. The young one being fast to the Top of the Arch at d, and its Head fix'd against the Glass; the Mother only contracts her Body, which by that Means becomes strait, as at a b, Fig. 390. which was before circular. While both its Extremities remain fixed against the Glass, the young one, which was also fastened to the Glass, does not follow the Mother when she withdraws, but remains in its Place, and its Tail d, by this Means is separated from the Body a b of its Mother.

Young Polypes shoot in Proportion to the Warmth of the Weather, and Quantity of Food the Mother eats; some have been perfectly formed in 24 Hours, and others not till the End of 15 Days. The first shot forth in the midst of *Summer*, and the other in a Season when the Water in which the Polype was contained, made * *Farenheid's Thermometer* descend to 48 Degrees.

They shoot forth from the Side of their Parent as a Branch from the Trunk of a Tree; and the Excrescence which is the Beginning of a Polype, is nothing but a Continuation of the Skin of its Mother, which is swelled and raised, nay even forms a Tube communicating with its Mother's Stomach, as appears from the following Experiment; for on choosing a large Polype of the second Sort, with a young one at its Side, which being placed upon a Slip of Paper in a little Water, the Middle of the young one's Body was cut, and the superior End of that Part which remained to the Mother was then open; next cutting the Mother on both Sides of the young Shoot, it became a very short Portion of a Cylinder open at both Ends, which being viewed through the superior and open End of the young Polype, the Light was sensibly seen in the Stomach of the Mother; but least there might yet be a Skin, which giving Passage to the Light, might nevertheless separate the two Stomachs, the remaining cylindrical Portion of the Mother was cut Lengthwise, and the two opposite Parts to that from whence the young one came out, were opened; and on observing it with a Microscope, not only the Hole t, of Communication, Fig. 391, was distinctly seen, but one might see quite through the End o, of the remaining Portion of the young one: Afterwards changing the Situation of these two Pieces of prepared Polypes, and looking through the last opening e, Fig. 392, the Day-light was seen through the Hole of Communication i.

* I must again remind the Reader, that these Thermometers are to be had at my Shop in *Fleet-Street*.

Mr. Trembley not being contented with making this Experiment once, repeated it seven Times, and met with the same Success in five of them.

This Communication between the Mother and its Young may be seen on feeding them; for after the Mother a b, Fig. 393, had eaten, the Bodies of its young ones swelled, being fill'd with the Aliments as if they themselves had been eating them at their own Mouths c d e i o.

In the long armed Polypes, the young ones do not shoot out from the Tail Part b c, but only from the Part a c, Fig. 396.

It is also remarkable, that Polypes do not only produce several little ones at the same Time, all remaining fixed to their Mother, but that even some of those little ones at that very Time have two or three young ones also, of which some are perfectly formed, as at Fig. 396.

This Figure is sufficient to shew with what Promptitude the Polypes increase and multiply. The whole Groupe formed by this Mother and her 19 young ones, was but an Inch and $\frac{1}{4}$ long, and one Inch broad Dutch Measure; the Arms of the Mother, and the little ones, for the most part were hanging down towards the Bottom of the Vessel, whilst the Polype was suspended on the Surface of the Water. This Mother eat about a Dozen of the aquatick Fleas every Day, and the little ones, which were in a State to eat, devoured amongst them about 20 every Day.

All the fresh Water Polypes, with Arms in Form of Horns, are Mothers, for each Individual of this Sort produce young ones.

Mr. Trembley says, he hath nourished a thousand Polypes, and never found one which did not multiply, after it had been well fed, and always observed their Motions very attentively, in order to discover if nothing passed between them analogous to Copulation in other Animals; but could never find any Thing like it.

He then put several Polypes of the second Sort by themselves, that he might be very sure they never had since their Separation any Communication with other Polypes; and took none for these Experiments but those which he separated from their Mothers himself; or those which being separated of themselves, were taken out of the Glass in which their Mothers were, before any other young one could be separated, with which it might have been possibly coupled; yet notwithstanding all these Precautions of causing these Polypes to live in a perfect Solitude, they all multiplied, eat, and continued to produce young ones, more and more in Proportion as they were fed.

Not only these which he first put alone have multiplied, but also many of their Descendants have also been put by themselves, from Generation to Generation, even to the seventh, with the same Precautions. Whence it appears that Copulation is in no wise necessary to the Production of a Polype.

Mr. Trembley hath also made an Experiment to prove, that a young Polype

lype had in itself the Principles of Fecundity, before it could be thought to receive it from its Mother, or any other Polype: For on cutting off a young one which only began to shoot, and at that Time was only like a little Button, as e, Fig. 387. it is seen alone and of its natural Size after it was cut off, at Fig. 394, and as it appeared in the Microscope at Fig. 395. it was put into a Glass by itself, and gradually increased, had Arms, and at last multiplied.

It is therefore very plain, that a young Polype, after being separated from its Mother, does not want the Company of another Polype to multiply.

And that even before Separation it hath within itself the Principles of Fecundity, since from that Time it multiplies.

That if this Principle is communicated to it by the Mother while they are united, there is no Sort of Communication between the Head and Arms of either.

Neither is there any Communication after this Manner by another young one, that comes from the same Mother at the same Time with itself. And that if this Principle of Fecundity is within itself, it certainly is in an imperceptible Manner.

If we have not from hence discovered how the Polypes become fruitful, we have at least learned, that in this Point they differ from the most part of known Animals, and by Consequence have made an Exception to the general Rule, that says, *there is no Fecundity without Copulation.*

After Mr. Trembley had made the foregoing Observations, he was still farther desirous of finding out, whether there might not be some other natural Manner of their multiplying by Slips, as the Branches of a Tree; or if, on the contrary, this Manner of multiplying would succeed when they are cut in one or more Parts. Mr. Trembley hath seen Polypes which have divided themselves into two Parts, after which each Portion became a complete Polype; whereby the same Re-production was performed as we have before remarked on cutting these Animals in two.

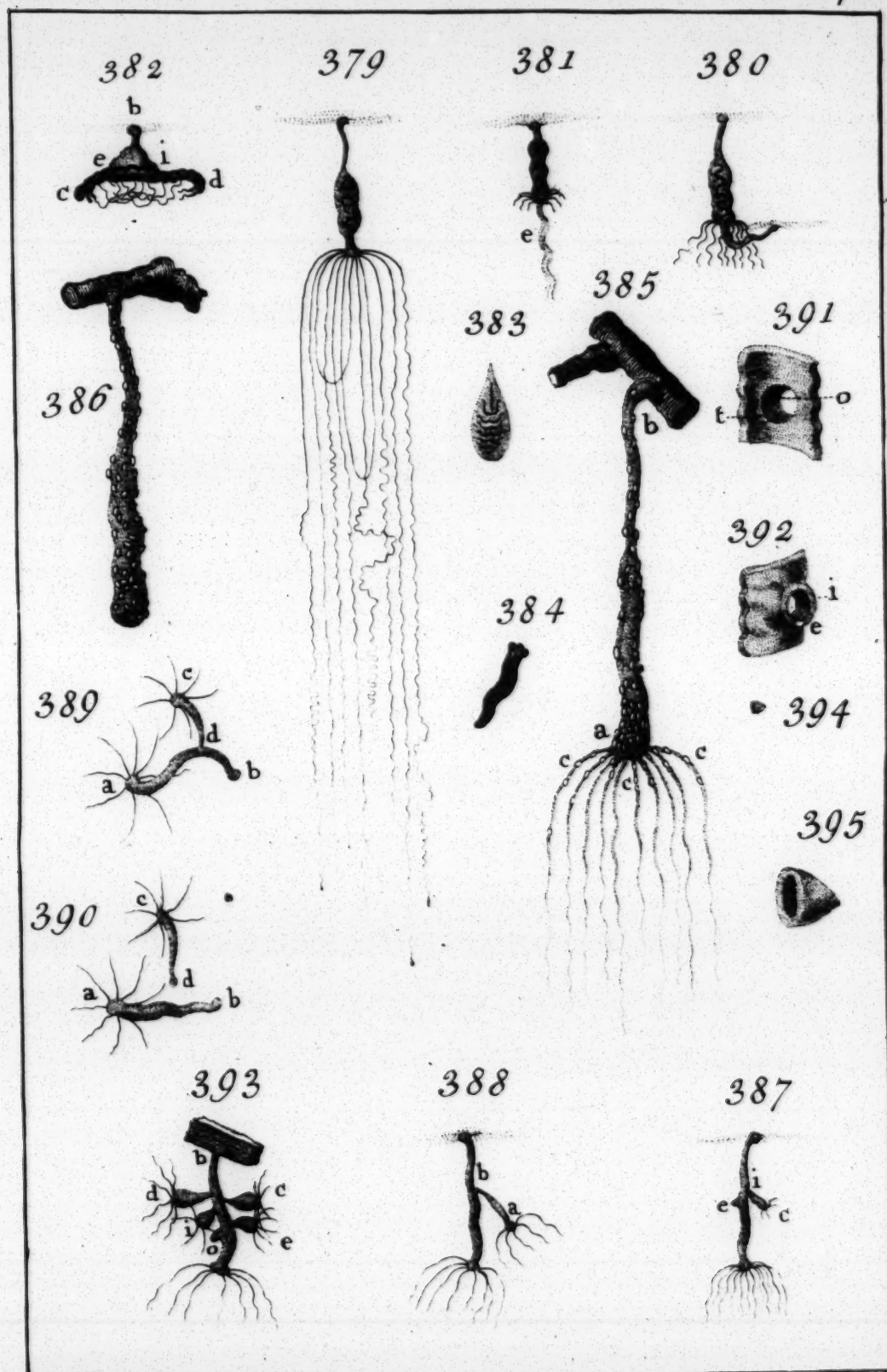
What hath been already said on this Head is sufficient to shew, that Polypes bear a nearer Resemblance to Plants than Animals, yet notwithstanding it is evident that they are Animals, because they eat and digest their Food.

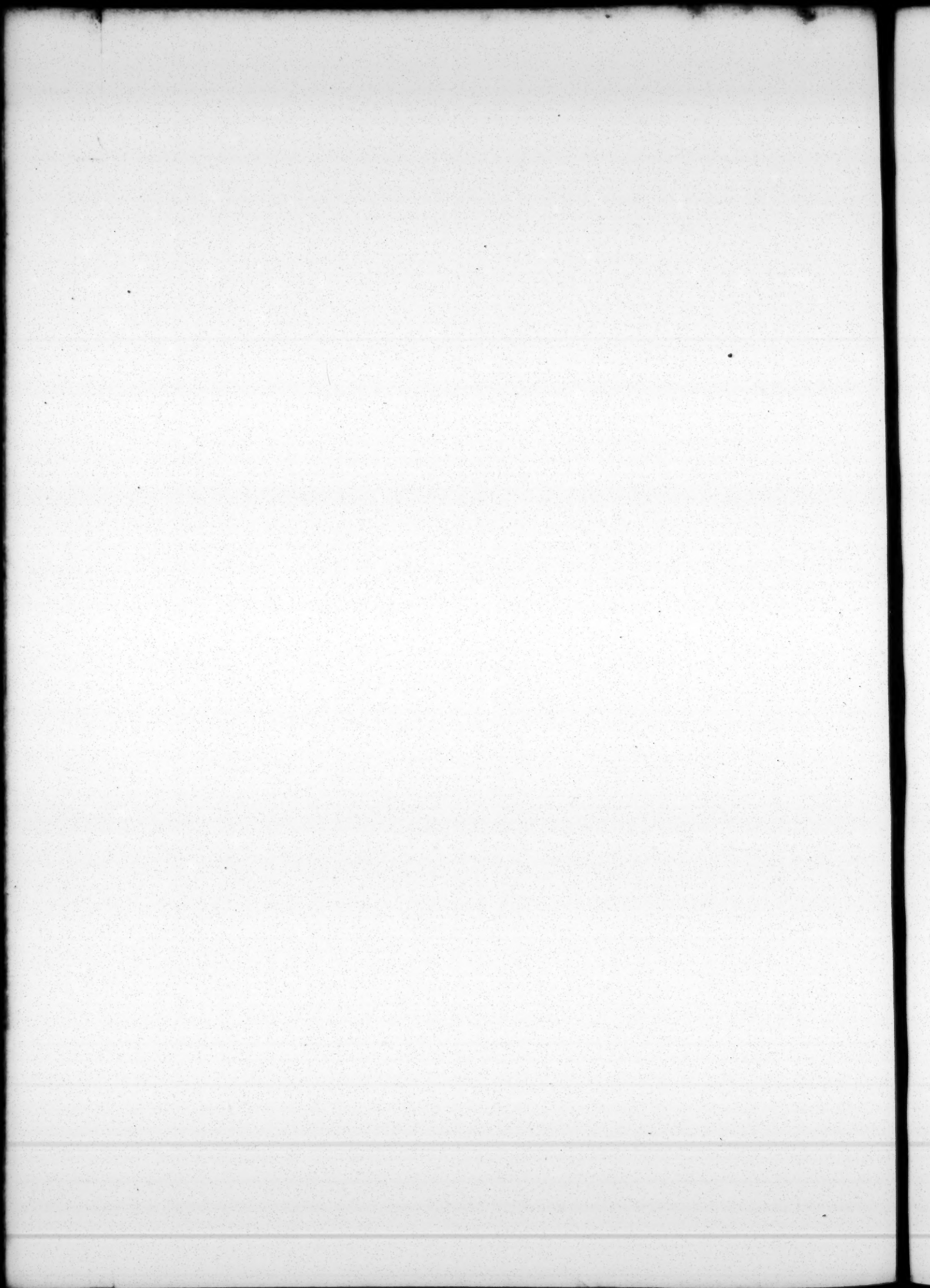
S E C T. IV.

Of cutting Polypes asunder and their Reproduction.

THE most extraordinary Part in the History of this Creature is this, that when cut into Pieces each Piece can repair itself and become a perfect Animal*.

* *Hist. de Polype. p. 193.*





To perform which put a little Water on a small Piece of Paper, whereon place a Polype, and wait a little while till it extends itself; then with a Pair of sharp Scissars cut it into two Pieces, Paper and all, and examine each Piece with a magnifying Glafs, to judge the Success of the Operation, putting each Portion into such a shallow Glafs as is represented Fig. 26. which does not contain above 3 or 4 Tenths of an Inch in Depth of Water, by which Means they may be always observed with a *magnifying Glafs*, or in the *Microscope*.

A, Fig. 397, represents the Head Part of a cut Polype, its posterior End b, being a little larger than that in a common *Polype*, and is sensibly open. In the Summer-time this first Part often walks, and eats the same Day it is cut.

The second Part, Fig. 398. hath its anterior End c more than ordinary open, and the Edges turned a little outwards, which afterwards folding inwards, closes the Aperture: The anterior End appearing then to be simply swelled, as at c, Fig. 399. This Part is never seen to change its Place before its Re-production is finished; the Arms shot out from its anterior End as those do in young Polypes, at first three or four Points begins to shoot, as at e, Fig. 400. and while these increase, others appear between them; before the Arms have done growing they can seize a Prey, and from that Time its Mouth is perfectly formed.

This *Re-production* is performed sooner or later, as the Weather is more or less warm. In the Height of Summer the Arms will sometimes begin to shoot in 24 Hours; and in two Days have been in a State to eat, but in cold Weather it will be 15 or 20 Days before the Head is formed.

If a Polype, having young ones, be cut transversely, the young ones continue to grow after the Section.

It often happens, that the second parts which have had no young ones at the Time of the Section, have had young Shoots before itself could eat, and before it had Arms.

In whatsoever Place a *Polype* was cut, whether at the Middle or near either End; the Experiment equally succeeded, and each Portion became a compleat *Polype*, which walked, eat and multiplied.

A *Polype* being cut close under the Arms, as at Fig. 401. and though small as it was, it became a compleat *Polype*, which at the Beginning was all Arms.

If a *Polype* be cut transversely into three or four Pieces; the posterior End of the first produces a Tail, the anterior End of the last a Head, and the intermediate Pieces acquire both Head and Tail.

To cut a *Polype* Lengthwise, it must be made to contract as much as possible, because the more it is contracted the larger its Body is: Therefore put the Polype upon a Slip of white Paper in a small Drop of Water, and when by touching, it is very much contracted, drain away the Water, whereby

whereby its upper and under Sides colapse, and the Polype becoming spread in Breadth, remains fixed upon the Paper; then with a sharp Pair of Scissars cut through both Paper and Polype, the divided Parts will adhere to the Paper like a Jelly, but may be removed therefrom to the Object carrying Glafs with the Point of an Hair Pencil, first dipped in Water, upon which it may be applied to the *Universal Microscope*; or if the Papers are thrown into a Glafs of Water, the divided Pieces will soon fall from them.

The Sides of a Polype cut longitudinally, roll themselves up different Ways, generally beginning from one of their Extremities, as at Fig. 402. and turns the Out-side of the Skin inwards; after some time it unrolls, and the cut Side forms itself into a Tube, whereof the Edges a b, and e i, Fig. 403. on both Sides meet each other, and re-unite themselves; sometimes they begin to join at the Tail End, at other Times they gradually approach all at once; when they begin to unite at one End, it is easy to distinguish that Portion which is joined c i b, from that which is not joined c a e, Fig. 404.

The Sides join so close, that from the first Moment no Scar can be seen; after which they become compleat Polypes, but with a less Number of Arms, and that in an Hour's Time, and in 24 Hours will seize and devour a Worm; in a few Days other Arms shoot and become as long as the rest.

Mr. Trembley cut a Polype into four Parts length-wise, as follows: After having cut it in two, in the Manner just shewn, he cut each of these into two also. These four Portions of the same Polype, had each of them six Arms, within six Days after the Section; and seven in four Weeks, they all eat and multiplied.

When a pregnant Polype is cut length-wise, the young ones continue to grow after the Section.

He hath also cut a Polype length-wise, and directly after cut the same transversely, and each of these four Quarters became compleat Polypes.

He likewise cut another, in Part length-wise, beginning at the Head, which became a Polype with two Bodies, two Heads, * and but one Tail. After having nourished this two headed Polype, by feeding it at both Mouths; he also split these Heads, and in a little Time it had four, and at last by cutting it after the same Manner, it had seven Heads, Fig. 405.

If a Polype be cut in Part length-wise, beginning at the Tail, it will soon have one Head and two Tails; and in this Manner the Number of Heads and Tails may be augmented by cutting, almost *ad infinitum*.

As all Sorts of these fresh Water Polypes form only a Tube or Gut, proceeding from one of its Extremities to the other, they may be turn'd Inside out as one would turn a Sack, viz. give a Worm to the Polype you

* *Hist. de Polype, p. 247.*

would perform this Experiment upon, and when it is swallowed, put the Polype into a concave Glass, or into the Hollow of the Object carrying Glass, with a little Water; afterwards press it near the Tail with an Hair Pencil, stroking it towards the Polype's Mouth, that the Worm within its Stomach may be forced partly out, as at *c e*, Fig. 412. its hinder Part *a*, remaining empty. As the Worm goes out, the Stomach enlarges prodigiously, especially if it goes out double, as is expressed in the Figure. When the Polype is in this State, make it contract as much as possible, which contributes much to the Enlargement of the Stomach. It must be here observed, that as the Worm is partly out of the Stomach, it keeps it open, then taking an Hog's Bristle in the right Hand, push it against the Extremity of the Tail *b*, till it enters into the Stomach, continuing gradually to advance the Hog's Bristle, till it hath quite turn'd the Polype. When it comes to the Worm which keeps the Stomach and Mouth open, it either pushes that out, or passes by on one Side thereof, and at last goes out of the Mouth, as at *a b*, Fig. 414. Sometimes the Polype is entirely turn'd at first, and then it covers the End of the Bristle *a b*, Fig. 413. In this Case the exterior Superficies of the Polype is become the interior, which now touches the Hog's Bristle, however it seldom happens that the Polype is entirely turned, but most commonly the Tail Part *a b* is out of the Mouth *b*, Fig. 414. and at the same Time a Part thereof is not turned; that is, its anterior End *a c*, which being terminated by the Arms, is folded over the turn'd End. Then to finish the turning, take an Hair Pencil in your right Hand, and the End of the Hog's Bristle in the left. Always holding the other End of the Bristle together, with the Polype in the Water, and stroke the End *a c*, which is not turn'd, very softly with the Hair Pencil, that Way which is necessary to turn it, that is to say, from *a* to *c*, Fig. 414. which is presently performed, at which Time it appears as at *a b*, Fig. 413. Then holding it in the Water, push it from *a* to *b*, with the Point of an Hair Pencil, and it will fall to the Bottom of the Glass without being put out of Order.

When it is first turn'd, the Mouth closes, and the Lips *a*, incline a little inwards; the Arms *a c* appear to join in a Bundle, and to come out of the Middle of the Polype's Mouth, as at *a*, Fig. 415.

After the Polype is turned, extend it as much as possible with the Hair Pencil, then taking an Hog's Bristle with a Knot near one End thereof, run the other End through the Polype's Body, near its Lips; at that Instant let the other End of the Bristle *e*, drop into the Water, and with the Point of the Pencil, push the Polype to the Middle *a*, of the Bristle, Fig. 416. then take out the Bristle and Polype, and put them into a Glass, *f, e, g, h*, taking Care that it only touches the Glass by its two Extremities *c* and *d*, that the Polype may be a great Way from the Bottom and Sides thereof, and the Knot End towards the Bottom; that if the Polype should

slide by its own Weight, it might not be able to disengage itself. This Method is used to prevent the Polype from turning itself back into its natural State, which they sometimes do in 24 Hours after they have suffer'd this Operation; and often after they have been turned, and spitted, to prevent them from returning, they have tore their Lips, and by that Means have formed two Heads.

Several young ones have been produced from these turn'd Polypes, which have also multiplied.

Sometimes they will eat in two Days after they have been turn'd, but generally not till 4 or 5 Days after.

Most of those Mr. *Trembley* turn'd, endeavoured to return themselves again, but could not entirely effect it, remaining like a Polype, partly turn'd, as at Fig. 406. the Skin of its anterior Part being applied upon the other, and forming a Kind of Pad at the anterior End a c, one Part thereof being turned, and the other not. Its Lips a, are no more at the anterior End, but are round that Part of the Body which is not turn'd back again, from whence also the Arms proceed, varying their Direction, sometimes pointing towards the Tail, Fig. 406. and at others are bent over the Head, Fig. 407. their anterior Extremity c, Fig. 406. formed by the Edges of the reversed Part c a, remain'd open, and some Days after began to close; and on being attentively observed, new Arms began to shoot near the old ones, and several Mouths* were also formed near the Middle of the Bodies of these Polypes, that is to say near the Place where their Arms joined the Body at a, Fig. 406.

A Polype partly turn'd back again, remains but a little while in that Situation, as at Fig. 406. The Place a, to which this returned Portion a c, was fixed to the other Part a b of the Body, became a little streighten'd, and the Portion a c formed a right Angle therewith, as is shewn at Fig. 408. where a c represents the returned Portion, and a b the other Part of the Body; the same Day another Head appear'd at e, and several Arms began to shoot, on one Side a o, of one Mouth a o n, which was formed on this Side; the other Side a n of this Mouth, being border'd by Part of the old Arms a d, a d. Next Day the Lips of the new Mouth was disposed in Form of a conical Nipple, and the new Arms smaller than the old ones. The same Day the returned Portion a c, Fig. 408. which the Day before made the right Angle c a b, with the other Part a b, not returned, was drawn nearer to this last Part, and made an acute Angle therewith, as at Fig. 409. where a c represents the returned Portion, and a b that Portion not returned. The doubtful Part e, remain'd as before; a Worm being given to it, fell upon the old Arms, was seized, conveyed to the

* *Hist. de Polype, p. 268.*

new Mouth, and swallowed in an Hour's Time, and the Portions a c, a b, and a e, Fig. 409. were swelled with the Contents of the Worm.

Four Days after, its Form was much different, as appears by a Comparison of the Figures 410, and 411, whereof a e represents the returned Part, and a b the Part not returned. Having now but one common Mouth a, Fig. 410. the new Arms are seen between a and t, the equivocal Part e as in the Figures.

This Form was changed but little in fifteen Days, as is seen on comparing the two foregoing Figures; the old Arms which were before between a and t being vanished, and a Head at u, Fig. 411. which was at first taken for a young one, but remain'd in the same State above three Months. This Polype had two young ones, which proceeded one from g the returned Part, and the other from f, the Portion not returned.

These Observations are sufficient to shew the Nature of a Polype, that is, partly turn'd back again, and the different Revolutions made in these Animals, are seen in the Figures 406, 408, 409, 410, and 411. which represent the same Polype, and the return'd Part always a c, and that Part not returned a b.

These Changes are not exactly the same in all Polypes, but vary considerably, seldom any two of a great Number being perfectly alike.

The Polype represented by Fig. 417. was turn'd, and the following Day returned Part of its Head, as at Fig. 407. which 7 Days after was formed into three Heads, as at Fig. 417. a b shews the Tail of the Polype, which remain'd turned. a d c g e, the Portion turn'd back again so considerably changed as to form three Heads d g e.

Fig. 418. exhibits the same Polype 14 Days older, a b the Portion which remain'd turn'd, a d c n g e o, the Portion turn'd back again, a d, n g, n e, its three Heads and Necks; marked d, g, e, in the foregoing Figure.

Fig. 419. is the same Polype 13 Days after it was in the State of Fig. 418. The Portion o c of Fig. 418. is parted from o to c, and the two Portions, b a c d o, and c n g e o, Fig. 419. are only fastened to each other by a Thread o, a b is the turned Portion, a c and o c two Portions, which in the preceding Figure are re-united, and marked o c, a d, n g, n e, and are the three Heads with Necks, and are marked by the same Letters, Fig. 418.

The two Portions held by the Thread o, Fig. 419. are seen as they were separated in Fig. 420. and 421. a b, Fig. 420. is the turned Part, and a d one of the Heads, n g, n e, Fig. 421. the two other Heads.

Mr. *Trembley* imagined, that if one Polype could be put into the Stomach of another, in such a Manner, that the external Superficies of the Skin of the first, should be applied to the internal Superficies of the Skin of the second, they might stick together, and become but one Polype.

To introduce one Polype into another, first feed some of them, and when they

they are swelled by the Aliments, their Mouths will be also extended. Take that Polype out of the Water, you would introduce into the Stomach of another, and put it upon your left Hand, making it contract as much as possible by stroking it with an Hair Pencil, in such a Manner as to force the Aliments out of its Stomach, and thereby cause its Mouth to open; then taking an Hog's Bristle in the right Hand, put the biggest End thereof into the Polype's Mouth, and thrust it to the Bottom of its Stomach. When this is done, place the Polype upon your Hand, into which this is to be introduced, causing it to open its Mouth, as in the other Polype, and thrust that which is upon the Hog's Bristle, into the Stomach thereof, and dip it into a Glas of clean Water, that you may examine it with a magnifying Glas; then to prevent the inner Polype from extricating itself, spit them both together upon an Hog's Bristle.

Fig. 422. represents two Polypes put one into the other, a b the exterior Polype, and c a, b d, the interior one; e f in all the Figures shews the Hog's Bristle which run through both the Polypes at e.

Fig. 423. is the same Polype, a i b the exterior one, c a i d the interior one; the Part i d by bending having ript up the Part i b of the exterior Polype, and by this Means got out.

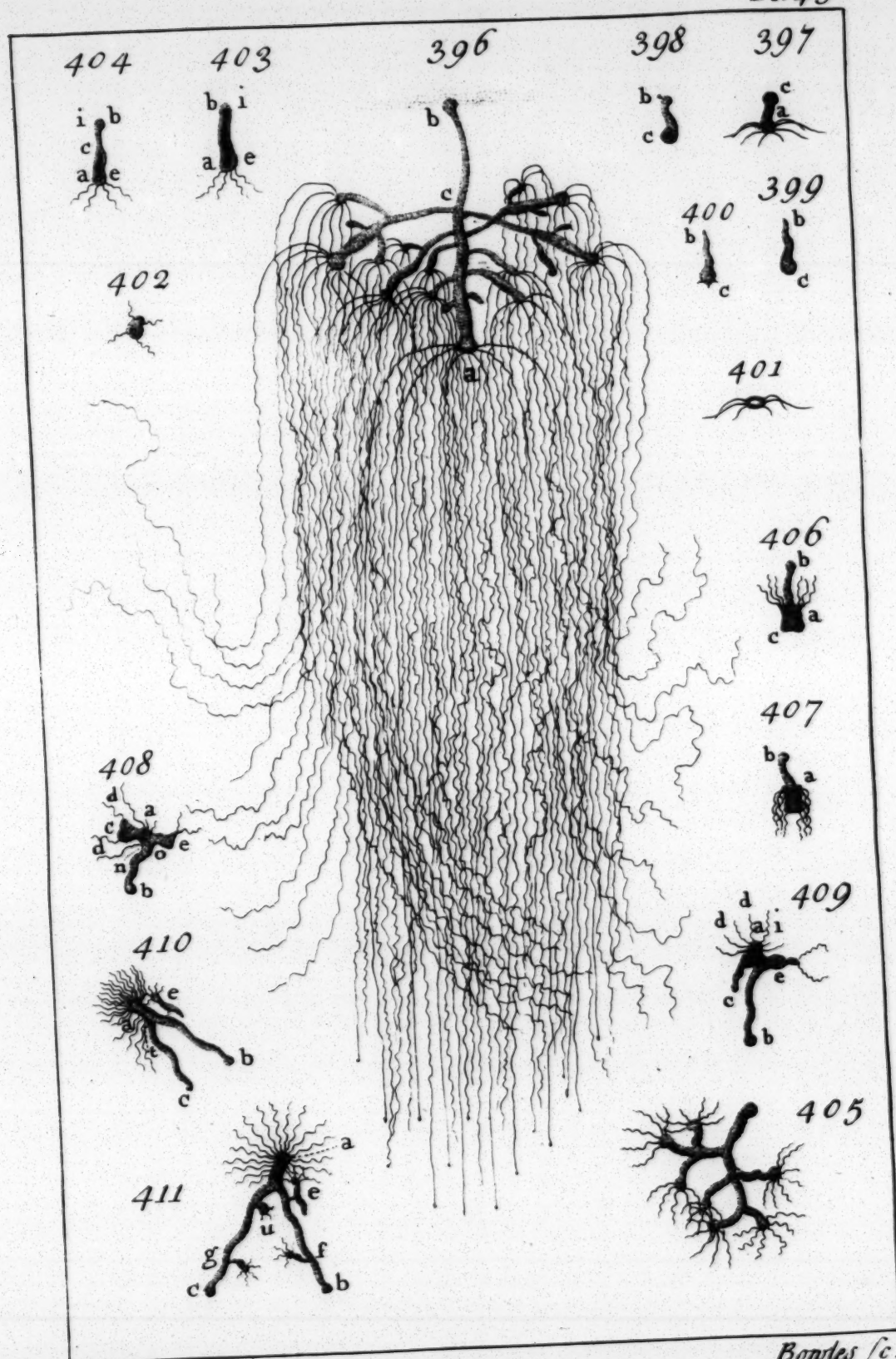
Fig. 424. shews the same two Polypes, whereof i d, of the interior, tore the Part i b of the exterior one farther up, even to e; where the Bristle at first ran through both the Polypes together: But when in the State represented by this Figure it pierced the interior one c a i d at e, and the exterior one a i b at i.

Fig. 425. represents the same two Polypes after the interior one a e b, had tore up the Lips of the exterior one c e d, and came out therefrom; they were separated in a few Days, and both of them did well.

Mr. *Trembley* hath given us a curious Drawing of an aquatick Animal which he calls a *plumed Polype*; it is represented as they appear in the Microscope at Fig. 426. The Plume and Length of its Body taken together are about $\frac{2}{12}$ of an Inch in Length, its Body very small, almost cylindrical, and Skin perfectly transparent. The Plume is a Continuation of this transparent Skin, very large in Proportion to its Body, and of a very remarkable Figure.

Its Base e a c is in the Form of an Horse-shoe, from the Edges of which proceed the Arms a d, a d, a d, whose Extremity is a little turned outwards, and are so close together, that each Plume contains 50 or 60. The Base e a c of this Plume serves the Animal for a Mouth; its Intestines may be distinctly seen through this transparent Skin at e b, f g, f a, and are of a brown Colour; after the Animal hath eaten, three principal Parts of their Intestines are visible, the Gullet e b, the Stomach f g, and the strait Intestine f a.

These Animals withdraw themselves into a Case i, k, l, B, I, m, that
seems





seems to be composed of the same transparent Matter with the Skin of the Body, which is fastened by its inferior Extremity i b, I B, to the Orifice of the Case; so that whenever the Animal retires into the Case the Skin of the Body is reversed. The Plume which is upon the Base c, enters with it, and appears, when all inclosed, like A B. After it is thus inclosed, it will soon come out again if it be left quiet.

When it is out of the Case, you may see a Tendon fixed by one End g, to the inferior Extremity of the Stomach; and the other at o, the Bottom of the Case. There is also another of these Tendons fixed to the Base of the Plume at a, and the other End of the same to the Bottom of the Case at o; it is by the Help of these two Tendons that the Animal draws itself into the Cell.

These *plumed Polypes* are seldom alone, but many of them placed together one by the Side of the other; and there are several of them that come out of the same Case, but by different Orifices, which is the Way they multiply.

At first there is a little Elevation upon the Superficies of the Case of an old one, after which the Body and Plume s t begin to appear; or when a young one begins to shoot the Base of the Plume and Points of its Arms u u u, shew themselves and increase as the Body enlarges.

They can only eat very small Animals, but of these they devour great Numbers in a Day.

The quick Motion of the Plume, or rather the Feather-like Arms thereof, form a kind of Whirlpool, into which most of these little Animals that are swimming near it are precipitated.

Every Instant one or two of its Arms suddenly bend into the Plume, and immediately replace themselves into their first Situation; the same Arm seldom bends twice together, nor do they touch the Prey but by their rapid and continued Motion cause a turning in the Water, which conducts those minute Animals into the Plume, although they make several Efforts to escape, the sudden Inflection of one Arm, adds a new Degree of Rapidity to the Torrent which hurries them into the Plume, where they are immediately swallowed, by the Mouth which is in the midst thereof.

C H A P. XXXV.

Of Vegetables.

S E C T. I.

THIS seemingly inferior Branch of the Creation, when carefully attended to, by the Assistance of the Microscope, exhibits to us an ample

ample Scene of the *Creator's* Wisdom, Curiosity and Art, in the wonderful Contrivance even of the most abject *Vegetables*, but more especially in the Anatomy of them; wherein may be seen the admirable Provision made for the Conveyance of the *lymphatick* and *essential* Juices, in communicating the *Air* as necessary to *Vegetable* as *Animal* Life, and more particularly in the Generation and Make of the *Seed*, wherein the Lineaments of the parent *Vegetable* are inclosed in Minature; and wherein also we see that *God Almighty* has by one Act of his creating Power provided for all succeeding Ages; and the future Posterity of each *Seed* does of Necessity produce its own Resemblance: For the Preservation of which, Nature hath endow'd some with light downy Wings, to be conveyed about by the Winds; others are laid up in elastick springing Cases, that upon bursting dart their Seed at convenient Distances, and others, &c. are planted by the Industry of the Husbandman.

The *Seeds* of *Plants* are inclosed in different *Sheaths* or *Cases*, till they are lodged in the *Earth*. Some are deposited in the very Heart of the Fruit, as the Kernels of *Apples* and *Pears*, others grow in *Cods* or *Shells*, as *Peas*, *Beans*, *Lentils*, *Poppy Seeds*, and *Cocoa Nuts*; some in wooden Shells, &c.

The Farina of Flowers appears to the naked Eye a kind of mealy Powder, which is found on the pendant Tops of almost every Flower; its Colour various in different Flowers, but its Structure constantly the same in Plants of the same Species. Here also the *Microscope* hath discovered surprizing Beauties, and hath shewn us, that this Powder is produced with the utmost Care in Vessels wonderfully contrived to open and discharge it, when it becomes mature, and that there is a *Pistil*, *Seed Vessel* or *Uterus*, in the Center of the *Flower*, ready to receive the minute Grains of this Powder, either as they fall of themselves, or are blown out of their little Cells. We are also taught by Experience, that the Fertility of the Seed entirely depends on this; for if the Farina Vessels are cut off before they open and shed their Powder, the Seed is unprolifick *.

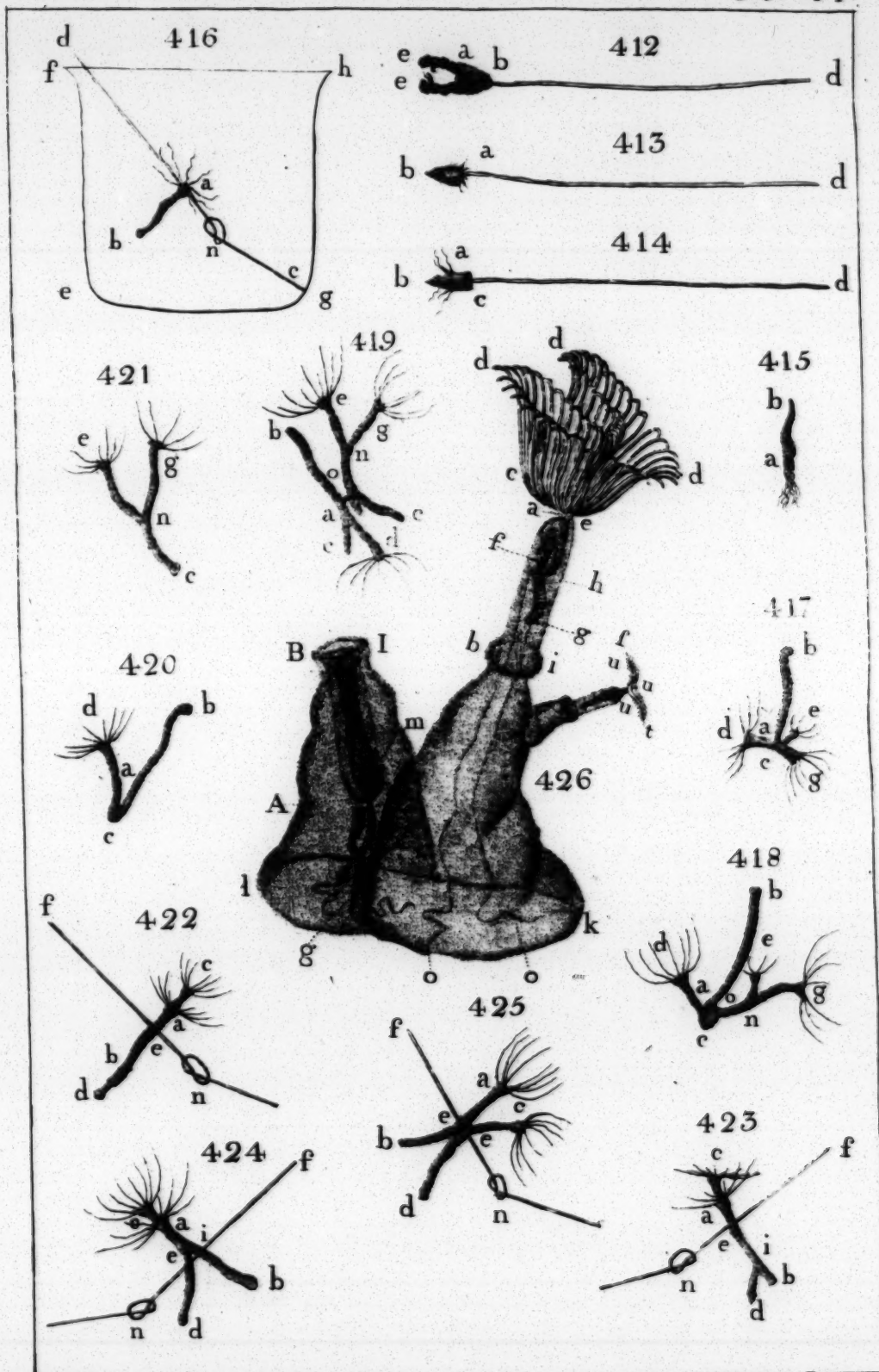
S E C T. II.

Of Seeds.

THE *Seed* is the last Product of a Plant whereby the Species are propagated; it is frequently the Fruit of the Plant, as is the Case in most Herbs: Sometimes it is only a Part inclosed in the Fruit, and that in Form either of *Grain*, *Kernel*, or *Berry*.

It is the natural Offspring of the *Flower*, and that for whose Production

* *Phil. Transf. No. 207.*





all the Parts of the Flower are intended; so that when this is once well formed, the several Parts of the Flower dwindle and disappear.

It is produced from the *Farina* of the *Apices* let fall on the Head of the *Pistil*, and thence forwarded to an *Uterus* at the Bottom thereof, divided into several Cells; where coming to receive the nutritious Juice of the Plant, it is first softned, then swelled, increased both in Matter and Bulk, and at length comes to its State of Maturity.

By the Use of the *Microscope* we discover in the *Seed* several Parts of the future Tree, only in Miniature; particularly a little Root call'd the *Radicle*, and the Stem call'd the *Plumule*.

I shall exhibit the curious and gradual Process of Nature in the Vegetation of the Seed; and first, in that of the Garden Bean, represented by Fig. 427. by which a general Idea of all Seeds may be easily formed. It hath a small Hole at a, that upon Dissection is found to terminate against the Stalk of the *Plumule*; its End is apparent at a, in the transverse Section of the Bean, Fig. 428. in which Figure the several Coats of the Bean appear, the innermost is every where twice, and in some Places thrice as thick as the outermost; and where it surrounds the Stalk of the Plume, it is six or seven Times as thick, as may be seen at b, Fig. 428.

The Hole a, Fig. 427. is not casually made by breaking off the Stalk, but design'd for the Nuture of the young Plant, and may be seen in several other Kinds, as *Peas*, *Vetches*, *French beans*, *Lupines*, *Lentiles*, &c. in other Seeds also, *Medica Tornata*, *Fenugreek*, *Goats-rue*, &c. in several of these it is not discernable without the Assistance of the *Microscope*; and in some not without cutting off Part of the Seed. When any of the above-named *Seeds* have been soaked in Water, several Bubbles will alternately break through this Hole on their being squeezed. All *Seeds* having thick and hard Covers, are also perforated in the like Manner; and those lodged in Stones and Shells, though not visibly perforated, yet the Stones and Shells themselves always are; when the Coats of the Bean are stripped off, the Seed appears; its main Body is divided into two *Lobes*, joined together at the Base of the Bean, as at Fig. 429. In young Beans, especially if boiled, these Lobes easily slip asunder; but in dry Beans are very difficult to be separated, unless they be first macerated for 24 Hours in Water. Some few Seeds are divided into more Lobes, as the *Cresses* into six, and some not at all, as Grains of Corn, &c. most other *Seeds*, even the smallest, are divided exactly into two Lobes like the Bean; that which joins the two Lobes together is called the *Stem* or *Radicle*, out of which the *Root* is formed when the Seed vegetates. This *Stem* is found in all Seeds; in the Bean and several others, it is situated somewhat above the thick End, in *Oak Kernels*, commonly called *Acorns*, *Apple-Kernels*, *Almonds*, &c. it stands prominent just from the End.

The Plume or Bud issues out of this Stem, and is that which afterwards becomes

becomes the Trunk of the Plant, separable in several already formed, tho' not displayed Leaves, which appear upon the sprouting of the Seed, and may be seen in the Seed itself by the Assistance of the *Microscope*.

The *Plume* is inclosed in a Cavity formed in the Lobes on purpose for its Reception, which may be seen at b, Fig. 429. it is almost of the same Colour with the Radicle, or little Root, on the Basis whereof it is sustained.

It is the first Part that appears out of the Earth; as in effect it is the first Part that appears out of the Membrane, or Cover of the *Seed*, there being a Hole over against it in the Membrane, through which it makes its Escape.

It is the Appearance of the *Plume* without the Cavity of the Grain, that makes what we call the *Bud* or *Germ* of a Plant.

In dissecting a *Bean*; if you hold your Knife aslope, and very gently bear upwards, an exceeding thin and transparent Skin will shew itself, just as the Knife enters; this Skin is not only spread over the Convex of the *Lobes*, but also upon the Flat thereof, and is extended both upon the *Radicle* and *Plume*, and so all over the *Bean*. This fine Skin vegetates imperceptibly, and the two Extremities of the Bag, which surround the Head of the Bud, expand and rise with it in order to preserve it, from all such Frictions as may injure its tender and delicate Texture *. Next to this is the *Parenchyma*, consisting of an infinite Number of extremely small Bladders, which may be seen in a very thin Slice of a *Bean* when applied to the *Microscope*, and appears like Pith while sappy in the *Roots* and *Trunks* of *Plants*; on cutting the *Radicle* transversely in several Parts, another Body of a quite different Substance from the *Parenchyma* or *Pulp*, will be found, which is also conspicuous in a transverse Section of the *Lobes*, and appears there like several small Specks, and of a different Colour from the *Pulp*: These are the several Branchings of the Tubes proceeding from the Radicle, and forming but one intire Trunk till it rises to a b, Fig. 430, from whence it issues forth into three main Branches, the middlemost directly into the Bud c, and the other two after a little Space, pass from e e on either Side into the *Lobes*, where they divide into smaller Branches, and these again spread into other more minute Ramifications, and terminating near the Verges of each *Lobe*, become a perfect Root.

This seminal *Root* being so tender, is difficult to be discovered, but may be come at by a careful paring off the *Parenchyma* in thin Slices Lengthwise, in new Beans, or if old Beans are soaked a considerable Time in Water, the same may be effected.

The Specks that appear on cutting the Radicle and Plume transversely are most visible in the *Bean* and great *Lupine*.

The seminal Root hath not yet been discovered in *Apples*, *Plumbs*, *Nuts*,

* Grew Ana. Plants, p. 4.

&c. partly from their Colour, being the same with that of the Pulp, yet in the *Gourd Seed* the main Branches with their several Ramifications appear immediately on separating the *Lobes*.

The *Parenchyma* of the *Lobes* is a kind of Meal intermingled with a nutritious Juice, or Sap of the Earth, forming a kind of Pap or lacteous Substance, which being filtered through the several Branchings of the seminal Root, are conveyed thro' the two small Tubes a and b, Fig. 430, into the Bud, which is gradually replenished therewith. When these seminal Roots have communicated all the Nourishment of the Lobes to the young Plant, they begin to wither, together with the Skin that covers them; the *Stem* or *Radicle* then also begins to take *Root* in the Ground for its future Subsistence.

S E C T. III.

The Coats of the Seeds.

HOW it was in its State of *Vegetation* hath just been shewn; it remains then to enquire into its State of *Generation*; for what in the other State was not apparent, or intelligible, will in this occur; and here also we shall find a large Field for the Employment of the *Microscope*.

The two general Parts of the *Seed* are its Covers and Body. The Covers in this State are usually four; the outermost, which is called the *Case*, and is of various Forms, sometimes a *Pouch*, as in *Nasturtium*, *Cochlearia*, &c. a *Cod*, as all Pulse; sometimes parted as *Sorrel*, knotted Grass, &c. The two next are properly the *Coats*, in a *Bean* especially, and the like; from whence the Denomination may run to the corresponding Covers of other *Seeds*; their Figures are sometimes kidneyed as *Alcea*, *Bebn*, *Poppy*; triangular, as *Polygonatum*, *Sorrel*, &c. spherically triangular, as *Mentha*, *Melissa*, &c. circular, in *Leucoium*, *Amaranthus*; globular in *Napus*, *Asperula*; oval in *Speculum Veneris*, *Tithymalus*; semi-globular in *Coriander*, semi-oval in *Anise*, *Fennel*, pirimidial in *Geranium Althææfol*, with many other Differences.

Sometimes glistening, as in *Venus Looking-Glass*, rough cast in *Catanance*, studded in *Beben*, *Blataria*; favous in *Papaver*, *Antirrhinum*, *Lepidum*, *annum*, *Alcea-Vesicaria*, *Hyoscyamus* and many more, * before the Seeds have lain long by; pounced in *Pbalangium Cretæ*, *Litbospermum*; ramified in *Pentaphyllum fragiferum erectum majus*, resembling the *Fibres* of the *Ears* of the *Heart*.

All *Seeds* have their outer Coats open, as in *Beans* and *Pulse*, as before

* Grew An. Plants, p. 45.

shewn, or else by breaking off the *Seed* from its Peduncle or Stool, as in *Cucumber*, *Cbicory*, &c. or by the Passage of a Branch or Branches, not only into the Concave near the Cone or Top of the Seed, but through the Cone itself.

The fourth or inmost *Cover*, is called the *Secondine*, a Sight of which may be obtained by cutting off the Coats of an Infant *Bean* in very thin Slices, at the Cone thereof, if not broke, it is transparent; if torn, it gathers up into the Likeness of a Jelly. In large old *Beans* it is not to be distinctly seen, but in most *Seeds* it may, even when full grown, as in *Cucumber*, *Colocynthis*, *Burdock*, *Carthamum*, *Gromwell*, *Endive*, *Mallows*, &c. though in these it is generally thin and difficult to be discovered, yet in some Kernels, as *Apricocks*, it is very thick, and remarkably so in some other *Seeds*.

The Concave of this Membrane is filled with a most transparent Liquor, out of which the Seed is formed, as appears on cutting an Infant *Bean*, or better in a young *Walnut*.

Through this Membrane, the lignous Body or Seed-Branches, in the inner Coat, shoot down in two slender Fibres, near the Base of the Radicle, one into each Lobe of the *Bean*, and there spread into a great many Ramifications, which convey the Juices on the Vegetation of the Seed, into the Radicle and Plume, as before described.

S E C T. IV.

Of the Seed Cases or membraneous Uterus.

THE Seed Case is a kind of fleshy Uterus, growing more moist and pulpy as the Seed ripens, but the Case itself whether called Cod, Pod, or by any other Name, is a membraneous Uterus, which grows more dry and hard as the Fruit ripens. In some the Seed Case is originally open, in others it opens when the Seed is ripe, and in others not at all till the Seed is sown.

Garden Radish-Seed breaks within as it ripens into several white dry Membranes, round about the Seed. Near the Sides of the Case run a Pair of vascular Fibres, from which branch forth several smaller Fibres, some towards the Sides of the Case for their Support, and others towards the Center thereof upon which the Seeds hang, Fig. 431.

Of those which open as soon as the Seed is ripe, some open at the Top, as *Poppy Heads*, Fig. 432, others on the Side, as most Cods; and some at the Bottom as *Coded Arsmat*, Fig. 433. the *Poppy Head* is divided by eight or ten Partitions into as many Stalls, and on both Sides the Partitions hang a most numerous Brood of Seeds.

Of those which open on the Side, some open on one Side, some on both, others with three Sides, some more, and others horizontally, or round about.

The Cod of a *Garden Bean* opens on one Side, and hath a two-fold Parenchyma ; in the outermost stands all the Vessels in several Parcels, from one of which, being larger than the rest, and at the Back of the Cod, shoots forth these lesser Vessels whereon the Beans grow ; the inner Pulp is wholly composed of Bladders, in which many of those Threads whereof the Bladders are wove, are so loose, as to be easily drawn out to a considerable Length, and are very visible when applied to the *Microscope*.

The Seed Case a b c d, of *yellow Henbane*, Fig. 434, opens on both Sides, from its Top at a, grows a Stem, which diminishes as the Case swells, and at last falls off. On the Sides of the Case run two opposite vascular Fibres, and as the Case gradually increases, it as gradually separates on both Sides in the Tract of the aforesaid Fibres as at b. The Case is lined with a smooth thin Skin, in whose Center is a great Parenchymous Boss c, being the Bed of the Seeds which lie all over as in a Strawberry ; throughout this Bed the Vessels d, for the Generation and Nourishment of the Seed are distributed, as may be seen in the transverse Section thereof at d, in which a very small Fibre, shooting from the direct Fibres obliquely into each Seed is plainly visible.

The *Seed Case* of a *Tulip*, whereof a, represents the Case intire, b is a transverse Section of it, and c the Case split down. Fig. 435, it opens on three Sides, from the midst of each proceeds a Partition, all meeting in the Center of the Case, and making six Divisions for the Seed. The Vessels are curiously disposed after they rise above the Stalk, being at first divided into three principal Branches, running along the three Angles of the Case, from which divers lesser Branches tend horizontally, and meet at the Middle of each Side ; whence they proceed through the Breadth of each Partition to their Edges, in the Center of the Case, where they are again distributed into very fine and short Threads, whereon the *Seeds* hang.

The Seed of *Anagallis* or *Pimpernel*, Fig. 436, is a little Globe opening horizontally into two Hemispheres, the uppermost falls off when the Seed is ripe, and so the Wind sows them.

The Seed-Case of *coddled Arsmat*, Fig. 433, neither opens at the Top nor on the Sides, but at the Bottom, being composed of four Sides, in the Center of the Case is a Column a, upon which the Seeds hang loosely. From this Mechanism that violent Ejaculation of the Seed is intelligible, which is not a Motion in the Seeds themselves, but contrived by the Structure of the Case, the Seeds hanging very loosely, not on the Sides of the Case, but on the Stem in the Center thereof, with their thickest Ends downwards, standing ready for a Discharge ; the Sides of the Case being lined with a strong Membrane, they perform the Office of so many little Bows

remaining fast at the Top b, are let off at Bottom, and forcibly curl upwards and drive all the Seeds before them.

S E C T. V.

Of the Number and Motions of Seeds.

Nature hath procured the Propagation of Plants several Ways, but chiefly by the Seed ; for the Production of which the Root, Leaves, Flowers and Fruit do all officiate ; and according as the Plant or the Seed it bears is more or less liable to be destroyed, Provision is made for the Propagation of either by a greater Number of Seeds, or otherwise ; for Instance, the Seeds of *Strawberries* being gathered, or eaten by Vermin with the Fruit, the Plant therefore is easily propagated by Trunk Roots ; the *white Poppy* being an annual Plant is highly prolifick, commonly bearing about four mature Heads, in each of which are at least ten Partitions, on both Sides whereof the Seeds grow, and on one fourth Part of one Side, about 100 Seeds, that is 800 on one Partition, which multiplied by 10 makes 8000, and this multiplied again by 4, the Number of Heads, gives 32,000 Seeds, the yearly Product of that Plant.

So also in *Typha Major*, the Seeds being blown off and sown with great Hazard, are prodigiously numerous, they stand altogether upon the Spike, and make a Cylinder at least six Inches long, and near $\frac{3}{4}$ of an Inch in Diameter. Nine of these Seeds set close together upon a Right Line make but the Eighth of an Inch, so that 72 make a Line of an Inch in Length ; but because upon the Spike, the Hairs belonging to the Seed come between them, we will abate 10, and count but 62 ; to which if $\frac{3}{4}$ be added (abating the Fraction, viz. 46.) makes 108, for the Circumference of the Cylinder, which being six Inches long, there are 6 Times 62 for a Line the Length of the Cylinder, which is 372 ; which Number being multiplied by 108, produceth 40176, the Number of Seeds that stand upon one Stalk : Therefore upon three Stalks which one Plant commonly bears, there are in one Year 120,528 Seeds.

As soon as the *Seed* is ripe, Nature taketh several Methods for its being duly sown, not only in opening the *Uterus*, but also in the Make of the *Seed* itself ; for first the Seed of many Plants which effect a peculiar Soil, as *Arum Poppy*, &c. are heavy and small enough without further Care to fall directly down into the Earth, and so to grow in the same Place where they had their own Birth. But if the Seeds are so large and light as to be exposed to the Wind, they are often furnished with one or more Hooks, to prevent their wandering too far from their proper Place, till by the Fall of Leaves or otherwise, they are safely lodged. The Seeds of *Avens* have one
single

single Hook, those of *Agrimony* and *Goose-Grass* many, both the former loving a warm Bank, and the last a Hedge for its Support; on the contrary, divers Seeds are furnished with Wings or Feathers, partly with the Help of the Wind to carry them when ripe from off the Plant, as those of *Asb*, *Maple*, *Orach*, &c. lest staying thereon too long, they should either be corrupted, or miss their Season, and partly to enable them to make their Flight more or less abroad; that by falling together, they may not come up too thick, and if one should escape a good Soil or Bed, another may light thereon. The Kernels of *Pine* have Wings, not unlike those of some Insects, but very short, in respect of the Weight of the Seed, they do not fly into the Air, but only flutter about upon the Ground; those of *Typha*, *Dandelion*, and most of the papous Kind, with many more, have very long and numerous Feathers, by which they are wafted every where, and to any convenient Distance.

Some Seeds are scatter'd, not by flying abroad, but by being spurted away as *Wood-Sorrel*, Fig. 437. which is effected by a white, thick and strong Cover of Tendons of a springy Nature, in which the Seed within its Case is inclosed. This Cover, as soon as it begins to dry, bursts open in an Instant on one Side, and is violently turned Inside out, and so smartly throws off the Seed.

The Seeds of *Harts Tongue*, Fig. 439. and all that Tribe, are slung or shot away by a curious Contrivance in the Seed Case; as in *Coded Arsmart*, or other like Plants, only there the Spring moves and curls up inwards, but here it moves outwards; every Seed Case stands upon a little Pedicle, a a a, Fig. 439. being of a silver Colour, and of a spherical Figure; it is girded about with a strong Tendon or Spring a, (whose Surface resembles a fine Screw, of a golden Colour, which breaks the Case, immediately upon its becoming elastick enough) into two hemispherical Cups, as at b c, and by that Means sling off the Seeds. These Cases grow in Furrows, d e, d e, on the Back of the Leaf, as at Fig. 438. in one of which of an Inch long are more than 300 of the above-mentioned Cases; and allowing 10 Seeds to every Case, makes 3000 Seeds; which multiplied by the Number of Furrows in one Leaf, with Allowance of the lesser Furrows, and that Sum by the Number of Leaves commonly growing upon one Root, amounts to above a Million of Seeds, * the annual Product of this Plant. The Seed is of a tawny Colour, flat and somewhat oval; of these ten thousand are not so big as a white Pepper Corn. Fig. 439. represents a few of the Seed Cases magnified; they were cut out of the Furrow at f, in the Leaf represented by Fig. 438.

Divers notable Means of Semination are observed by other Authors; Mr. Ray tells us, that a Quantity of Fern Seed, laid in a Lump, on a Paper,

* Grew. Ana. Plant, p. 119.

the feminal Vesiculæ are heard to crackle, burst, and, by the *Microscope*, the Seeds are seen to be projected to a considerable Distance from each other.

Dr. *Sloane* observes, that the *Gentianella flore cæruleo*, or Spirit Leaf, requiring wet Weather to be sown in, as soon as the least Drop of Rain touches the End of the Seed Vessels, with a smart Noise, and a sudden Leap, it opens itself, and with a Spring scatters the Seed.

Other Plants sow their Seeds by inviting Birds by their agreeable Taste and Smell, to feed on them, swallow them, and carry them about; thereby also fertilizing them, by passing through their Bodies. In such Manner are Nutmegs and Mizzletoe sown and propagated.

S E C T. VI.

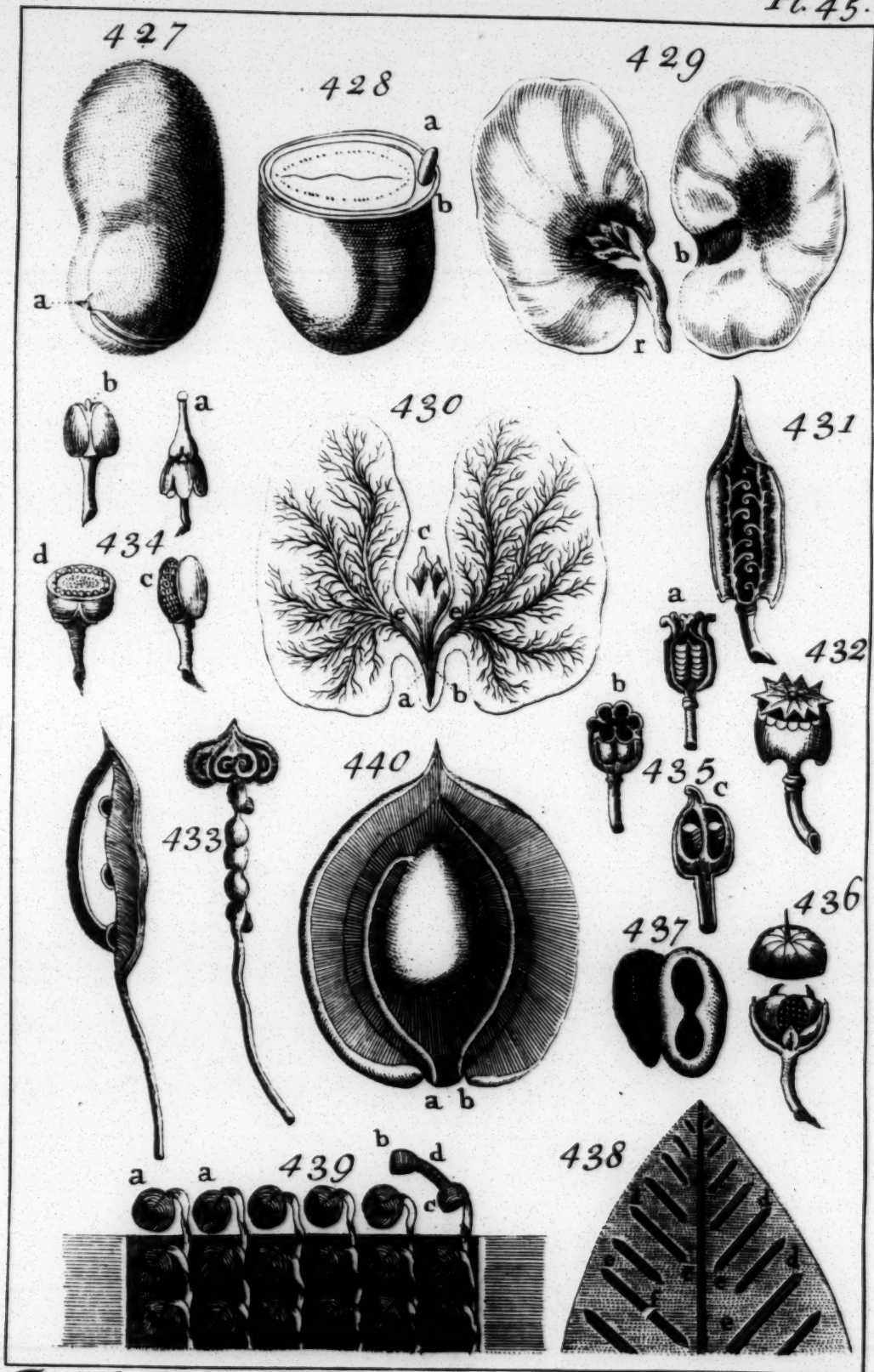
Of the Covers of the Seeds.

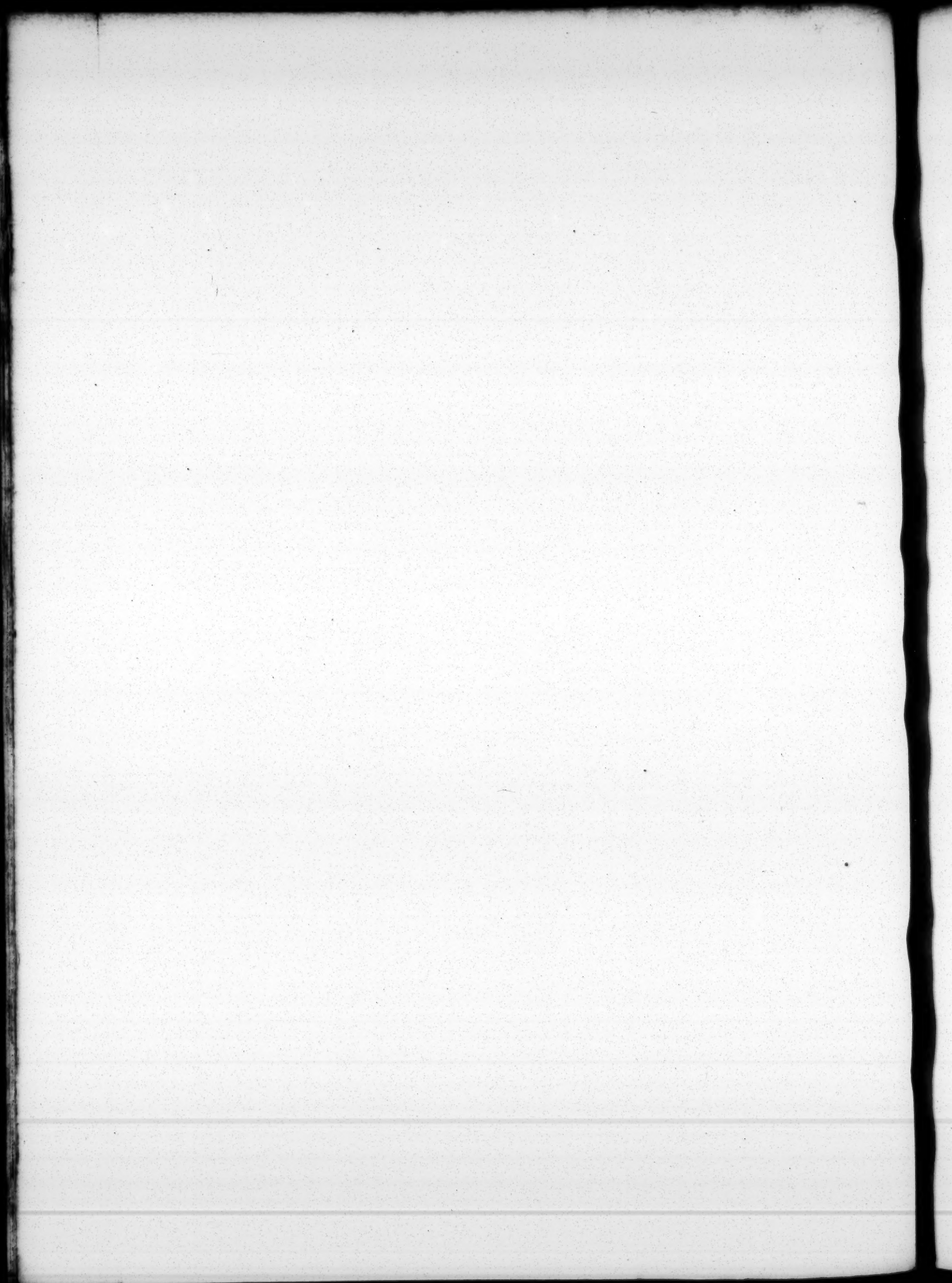
THE next Step which Nature takes, relates chiefly to the Growth of the *Seed*, when sown, and for this Purpose the outer Covers are somewhere furnished with Apertures, sufficient for the Reception of alimental Moisture, to be received from the Ground, and for the shooting forth of the young Root into it; as in the Seed of a *Gourd* at the Bottom, in a *Bean* on the Side, and in a *Chestnut* at the Top, in which Place the young Plant always lies, and puts forth in the said several Seeds. The Seed of *Palmi Christi* falls to the Ground, not only in the usual Covers, but also in the said Case.

If the Cover of the Seed be stony, and very hard, it is divided into several Pieces, whereby they easily cleave asunder: The Shell of a *Hazel Nut*, divides on the Edge, and the Cleft begins at the Point, where the Root stands and shoots forth; the Shells of some *Walnuts* cleave into four Parts, and the Stone of *Bellerick Myrobalan* into five: The Covers and Husks of some Sorts of Grain, as *Millet*, are folded over each other, the better to give Way to their tender Sprouts.

The Covers of all, or at least the far greater Number of Seeds, are three, and sometimes four, even those of stoned Fruits have three, besides the Stone; in *Gossypium* there are two under that lin'd with Cotton. The Seeds of *Cucumbers*, *Goat's Beard*, *Broom*, *Scabious*, *Lattice*, &c. although so small, have plainly three Coats; in some of these, and in many more, only two are distinctly visible, except in the State of Generation. In the upper Coat the Seed Vessels are disseminated; the second is at first a mere Pulp, which afterwards shrinks up, and sticks close to the upper. The third or inmost more dense; and if it be thin, for the most Part transparent; whereby the Seed seems to be sometimes naked while it lies therein, as in *Almonds*, *Cucumbers*, &c.

In





In *Melissa*, and some other Seeds, it comes finely off, on being soaked in warm Water.

S E C T. VII.

Of the Fœtus, or true Seed.

AMong Seeds of the thinner Covers are those of all Sorts of *Corn* and *Grass*, different from that of most other Seeds. The main Body being of one entire Piece, doubled in the Form of a Pair of Lips. In the Seeds of *Dates*, and some other like Plants, that which is generally called the Stone, seems indeed to be the main Body of the Seed, doubled or folded up in the same Manner as Corn, to which that Part which becomes the Plant is annexed. In Corn it is placed in the Bottom of the main Body, but here in a small round Cavity in the Middle of the Back.

For the most Part the main Body is divided into two Lobes, plainly to be distinguished in most *Kernels*, and other large Seeds, and not difficult in many lesser ones, as in *Viola-lunaris*, *Scabious*, *Doves-Feet*, &c. if slipped out of their Covers before they are full ripe; in *Hounds Tongue* they are of a circular Figure; in *Cucumbers*, oblong, with some visible Branches of the seminal Root, &c.

In the foregoing Seeds, the Lobes lie flat one against another, but in *Garden Radish* they are folded up, so as to receive the Radicle into their Bosom. In *Holy-Oak* the Lobes are plaited over each other. In Cotton Seed they are very broad and thin, and their Folds curious and very numerous.

Many of the Seeds, with bulky Covers, are not divided into two Lobes, being in a Manner of one Piece, as all the bulbous Kind: In *Flag* it is above 20 times bigger than the Seed within it, and consists of Bladders radiated towards the Seat of the Seed, and these disposed in parallel Lines running lengthwise.

But the greatest Number of Seeds with bulky Covers, are divided into two Lobes. In the *purging Nut* of *Angola*, if the Shell be taken off, the upper Covers, [dried and shrunk up] seem to be but one: In these the spermatick Vessels are branched, and under them the thick and inmost Cover; which being cut down the Middle thereof, shews the true Seed, consisting of two veined Leaves, as white as Milk, joined together with the Stem or Radicle at their Base, and sunk into a Hollow made in the Cover. The same is also observable in the *Barbadoe Nuts*, *Ricinus*, *Americanus*, and some other *Indian Fruits*.

In the foregoing Fruits, the Bulky is very soft, but in *Nux Vomica Officinarum*, it is nearly as hard as a *Date Stone*; in this, and the foregoing, the
Seeds

Seeds are large, but in others are so small, that they are scarce discernable without a *Microscope*, as in *Staphisagria*. The thick or inmost Cover is conical towards the Base, at whose Point is a little Cavity where the Seed is lodged; the Root thereof pointed, and Lobes rounded at the Top. In *Peony* the same Cover is soft, white, and of an oval Figure, the Part used for Medicine, is thought to be the Seed itself, but is near 200 times bigger than the true Seed; which lies in a little Cavity near the Bottom of the Cover, with a blunt Root, and two pointed Lobes.

In *Coffee-Berries*, the Seed lies in the inner Cover, near the Top; the Back of the Lobes are veined like two minute Leaves, and joined to a long Root.

The Seed of *Stramonium* is inclosed in a bulky Cover, which being soaked in Water, and carefully cut about the Edges with a sharp Razor or Penknife, its Seed may be taken out entire, and examined by the *Microscope*.

S E C T. VIII.

Of the Buds of Seeds.

THE Stalk of the Plant rises up from between the Lobes, which may always be seen, in some by the naked Eye, and in others by the *Microscope*; in many Plants Nature sees fit only to lay the Foundation thereof in a round Node, as in *Viola lunaria*, &c.

But in most Seeds is formed a true Bud, consisting of perfect Leaves, in some two, others four, &c. In *Bay-berry* only two, very small, but thick, and finely veined; in the Seed of *Carduus Benedictus*, they are also two, pointed at Top, and situate a little Distance from each other, for the two next to rise up between them.

In some Herbs, although the Bud consists but of two perfect Leaves, yet they are very conspicuous, not only in the larger Seeds, as *Phæscolus*, or *French Beans*, but in small ones two, if examined by the *Microscope*, as in the Seed of *Hemp*. A B, Fig. 441. in which the two Leaves are plaited, and set Edge to Edge, c shews the other Part of the Seed which was separated to lay the Bud fair to View. In the Seed of *Senæ*, the Bud hath four Leaves: In the Seed-Bud of an Almond C, D, Fig. 442. there are six or eight, and sometimes more distinct Leaves visible, if by a dextrous Separation of the Outer, the Innermost are laid open, they are folded inward one over the other, as appears at D, which represents them open, and at C the same Seed-Bud is seen shut.

The Lobes of the Seed, and so likewise the Stalk and Bud, consist of a Skin, Parenchyma and branched Vessels, as before described; all which are apparent to an Eye armed with a *Microscope*.

The

The first Skin, as in *French-Beans*, may be easily separated from the Parenchyma, especially if the Bean be soaked in Water for some Days, it will slip easily off, and will be found to consist of Bladders, smaller than those of the Parenchyma, and intermix'd with a kind of lignous Fibres which give a Toughness to the Skin. The branched Vessels run through the Parenchyma, and compose the seminal Root in the Lobes, being no where extended to the Circumference of the Lobes, but are all inosculated together at a considerable Distance from it; all meeting therein in one solid Nerve, but in the Stalk are dilated into an hollow Trunk, filled with a Pith composed of Bladders, which in the Stalks of *French Beans* is very conspicuous; they consist of Sap and Air Vessels as the other Parts of a Plant, not running collateral, the latter being sheathed in the former, and are plainly visible in the *Microscope*.

S E C T. IX.

Of the Generation of the Seed.

AS a *Garden Bean* was chose to shew the Manner of the Seeds Vegetation, so an *Apricock* is very fit to observe and represent the Method Nature takes in its *Generation*.

A proper Uterus is first prepared, both to keep the Membranes of the Foetus warm and succulent, and to preserve and secure it afterwards till it takes Root in the Ground. For this Purpose both the Pulp and Stone of the Fruit are necessary; but first the Stone, the Pulp being only necessary to form the Stone, the petrifying of that Parenchyma which is the Ground of the Stone, being effected by the sinking of the Tartar * thereinto; for

It is evident on cutting a young *Apricock*, and then with a sharp Razor shaving off a thin Slice, and viewing it through the Microscope, that at first the Ground of the Stone is a distinct and soft Parenchyma, composed of Bladders, as the Pulp itself is, which Bladders, as it hardens into a Stone, fill up and disappear.

This Parenchyma takes its Rise from the Pith, as the Pulp does from the Bark, and composes the greatest Part of the Stone; its Inside is lined all over with a thin Skin, covering the Seed Branch on its first Entrance into the Hollow of the Stone; which Skin is also composed of exquisitely small Bladders, by which Means it soon becomes a very hard and dry Body.

The Stone being made hard and dry, could never be sufficiently softened (to give Passage for the Vegetation of the Seed) by lying under Ground, did it not easily cleave in two; for which Purpose the Skin of the Fruit is

* Grew. *An. of Plants*, p. 209.

immediately concerned ; for in a transverse Slice of a young *Apricock*, if it be cut with a sharp Knife, this Skin may be seen (when applied to the Microscope) fairly doubled inwards from the two Lips a b, a b, of the Fruit, Fig. 443 and 444, and from thence continued through the Pulp and Stone itself into the Hollow thereof, where it meets and is united with the Lining before-mentioned ; and as it conduces towards the drying of the Stone, so also it renders it cleaveable in that Part where it runs through it.

Nature having thus provided a convenient Uterus, her next Care is about the Membranes of the Foetus, these are three apparently distinct, and in many Respects different from each other.

The first of these, Fig. 443. represents a transverse Slice of a young Apricock near the lower End, shewing the Duplication of the Skin half Way through the Stone. Fig. 444. a transverse Slice cut through the upper End, shewing the Duplication of the Skin quite through the Stone ; and at a b, Fig. 446. is shewn the Branches which run through the Stone to the Flower and Seed, in a well grown Apricock cut Lengthwise.

The outermost of these Membranes takes its Rise from the Parenchyma, and surrounds the Seed Branch, and upon its Entrance into the hollow of the Stone is expanded into two Bladders, one within the other ; whereof one becomes the Lining of the Stone, the other the outer Membrane, and is best seen on cutting a young Apricock when it is about half an Inch long through the Middle, or from the Seat of the Flower to the Stalk, between the two Lips a b, Fig. 443. At this Age the outer Membrane hath a full and firm Body, and is composed of Bladders, as may be plainly seen on its Application to the *Microscope*.

The Vessels contained in the Seed Branch, are distributed throughout this Membrane, beginning a little below its smaller End, and running round both Ways, meet in the Middle of the greater, where they are all inosculated and form a kind of umbelical Node, as at a, Fig. 445. from whence they strike deeper into it till they arrive at the middle Membrane, where they become invisible ; these Vessels convey the Sap to the middle Membrane, whose Bladders are more angular and amplified towards the Center, being at least two hundred * Times bigger than those of the outer Membrane.

This middle Membrane is so called from the State and Condition it hath upon the Augmentation of the Seed, at which Time it obtains the Name of an Involucrum †, but originally is every where entire without any Hollow, filling up the Cavity of the outer Membrane like a soft and delicate Pulp. After a short Time a small Channel appears therein, running from the Bottom to the Top ; at first no wider than to receive a human Hair, and then only visible in a transverse Slice, and that not without a *Micro-*

* *Grew. An. Plan.* p. 210. † *Ibid.*

scope ;

scope; but when grown a little wider, may be seen if the Membrane be carefully cut Lengthwise, at which Time it is dilated into two oval Cavities, e f, Fig. 446. one at each End, into which a most pure Lympha continually owzeth, and is therein reserved for the Nourishment of the Seed, and also passes freely from one to the other.

A few Days after this, the inmost Membrane begins to appear like a soft Bud growing out of the upper Cavity, being joined to its lower End by a short and tender Stalk; from whence it is produced into a conical oval Figure, answerable to that marked g in the Cavity, Fig. 447. This Membrane, though soft and full of Sap, is composed of Bladders, three hundred Times smaller than those of the middlemost, by which Means the Seed is so well guarded, as not to be supplied with any other Part of the Lympha but the purest, and that only but by slow Degrees.

If with a steady Hand this Membrane be pulled very gently upwards, it will draw a small transparent String after it to the Bottom of the middle Membrane: This said String, though for the greater Part parenchymous, is nevertheless strengthened with some lignous Fibres, which seem to be a Portion of those that are inosculated at the Bottom of the outer Membrane, and thence produced through the middlemost under the Channel which joins the two oval Cavities, till at last they break forth into the upper Cavity, where they form this inner Membrane, which is originally as entire as the middlemost; but as it increases, becomes a little hollow near the Cone, and the aforesaid lignous Fibres fetching their Compass from the Base, shoot forth into the Cone, and make a very small Node therein, for the first Essay towards the Generation of the Seed, as at h, Fig. 448. which are spun out to the utmost Degree of Fineness for that Purpose. In this Figure the inmost Cover is laid open to shew the Seed itself.

When this Node is grown to about the Size of the fifth Part of a Cheesemite, it begins to be divided by a little Indenture towards the Top, as at k, Fig. 449. which gradually grows deeper till the Node is distinguished into Lobes or thick Leaves; and as these increase, their Base is contracted into the Radicle, or that Part of the *Seed* which becomes the Root; at this Time the *Seed* is so extremely small, that the Lobes cannot be separated; but it is probable, that as soon as the Radicle is finished, the next Step is the pushing forth another Node between the Lobes, in order to the Formation of the Bud, and so the Perfection of the Seed.

This being done, or in doing, the Stalk of the Seed is more and more contracted at Bottom, and hangs at the inner Membrane only by an extremely small and short Ligament m, Fig. 450. which at last breaks; and then the Seed, as Fruits when ripe, falls off and lies loose in the inner Membrane, which gradually shrinks up and becomes more hollow to make more Room for the farther Growth of the Seed.

In *Malpighi's* Life was a Debate between him and Seignior *Triumphetti*,

Provost of the Physick Garden at *Rome*, whether the whole Plant be actually contain'd in the *Seed*? The Affirmative is maintain'd by *Malpighi* with cogent Arguments; among which this is one, that in a *Kidney Bean*, ere sown, the Eye, assisted with a *Microscope*, easily discovers *Leaves*, a *Bud*, and even the Knots or Implantation of the Leaves on the Stem. The Stem itself is very conspicuous, and plainly consists of woody Fibres, and Series's of little Utricles. Whereas Seignior *Triumphetti* had objected, that by Poverty, Transplantation, &c. several Plants degenerate into others, particularly Wheat into Tares, and Tares again into Wheat; in Answer to this, which is one of the strongest Objections against that Opinion, *Malpighi* replies, that he is not fully satisfied as to the Truth of the Objection; for that both himself and his Friends making the Experiment, no Metamorphosis of the Wheat succeeded: But granting the Metamorphosis, it is the Soil, or the Air, or the Culture is in Fault. Now, therefore, from a morbid, and monstrous Condition of Nature, there is no inferring her genuine and permanent State.

That Experiment related in the following Section, of the Orange Kernel, which Mr. *Leeuwenboek* made to germinate in his Pocket, is a plain Demonstration, that the Plant and all that belongs to it, was actually in the Seed itself.

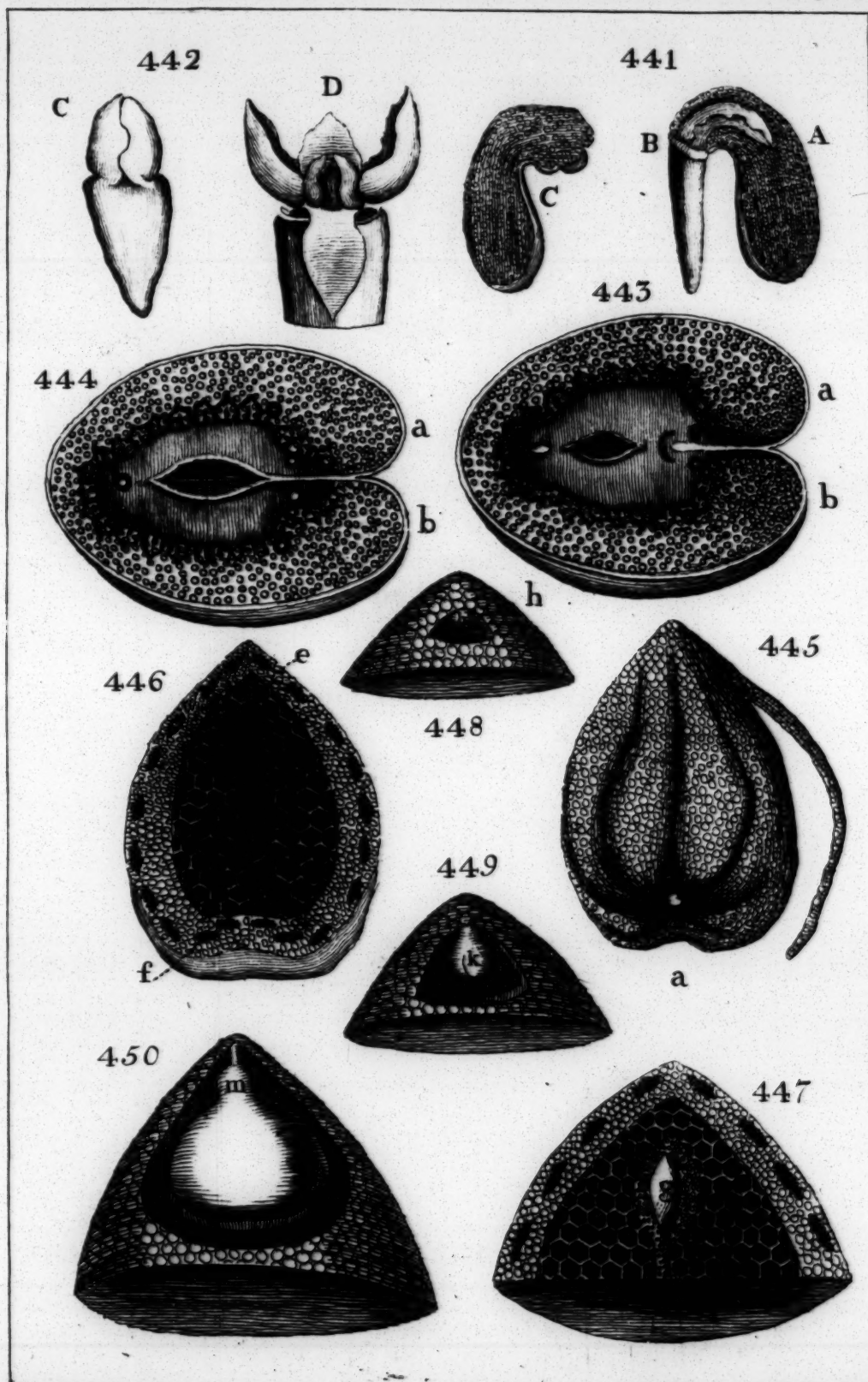
S E C T. X.

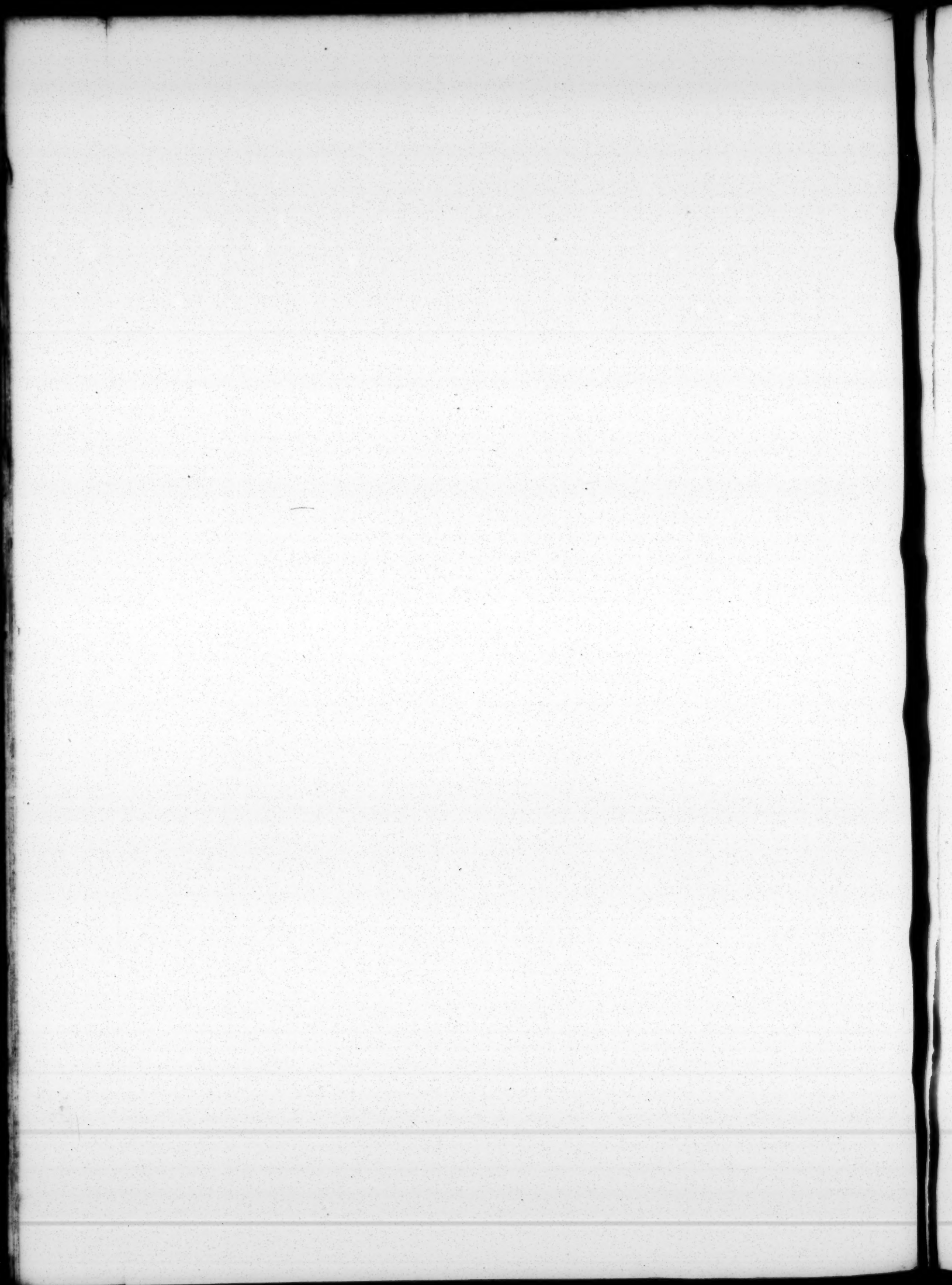
Of the Seed of Oranges.

THE Process of Nature in the *Vegetation* of *Plants*, is very accurately deliver'd by Mr. *Leeuwenboek*, to the Effect following, by an *Orange Kernel* which he made to germinate in his Pocket, viz.

The *Kernels* of *Oranges* being divested of their outer Membrane, will appear as Fig. 451. on one Side of which lies a String *a*, which causes a little Protuberance in the first Skin; from this String, not only the Seed, but also the Plant within it, receive their Increase and Nourishment, and to which through the second Membrane, it extends its small Vessels to the Seat of the *Plant*. Mr. *Leeuwenboek* was of Opinion, that this String does actually comprehend in itself, as many distinct Vessels as are to be found in the *Orange-Tree* when arrived at its full Maturity *. For, says he, if all these Vessels were not in the young Plant, whilst it lies involved in the *Kernels Matrix*, whence could they afterwards proceed? Fig. 452. represents Part of the same String, cut a-cross, and greatly magnified, which at K L M N, has Abundance of exceeding small Vessels, but very difficult to be

* *Phil. Transf.* No. 287.





perceived. About I H N M, they grow larger, and consequently are more visible. B, Fig. 453. represents a Seed divested of its Membranes, which seemed to have but one Plant within it, tho' often there is two, and sometimes three distinct Seeds with their Plants contain'd under the Membrane of an *Orange Kernel*; these Seeds, with their inclosed Plants, are easily divided into two Lobes; which are framed by Nature, to nourish the tender Plant within, till it is able to stand alone, and draw its Subsistence from the Earth about it; having split the Seed into two Parts, they are represented by C and D, Fig. 453. in the first, is Part of the Plant, which would have become a Tree, and is no bigger than a Grain of Sand to the naked Eye. The Counterpart of the said Kernel is represented at D, with the Concave, in which Part of the Plant lay. Fig. 454. represents the last mention'd Plant, as it appear'd in the Microscope, whereof Q L M is partly that which Nature intends for the Body and Root of the Tree; M N O P the Leaves with which the young Plant is already provided, O P that Part of the Leaves which is somewhat protuberant, by Reason of the small inclosed Leaves, M N, and P Q shews the two Sides of the Plant torn off from the Kernel, to which it was united, and from which it received its Nourishment. Fig. 455. S T V, shews the same Plant a little turned about before the *Microscope*, in order to represent the two largest Leaves, between which, according to all Appearance, a great many small ones are shut up. If the Leaves be cut a-cross, some of the included ones may sometimes be discerned, and on cutting that Part of the Plant which is to be the Body and Root of the Tree, that which was designed for the Pith, and even the Wood itself may be discover'd.

Fig. 456. shews the Root when the Plant vegetates, T V and W X the two Halves of the Kernel, and Y that Part which is to become the Body of the Tree.

Fig. 457. represents the young Plant of 12 Days Growth, whereof A C D shews the Root, and F G that Part which is to be the Tree, D E the Seed or Kernel, which being surrounded with its Membrane, which was taken off the better to expose those Parts to view, that serve for the Nourishment not only of the Root, but of the upper Parts of the Plant likewise, as also the short String D. Thus we may see how small a Particle, that is no bigger than a Grain of Sand, * as the Plant was at first, is increased in Bulk! and all this is brought about by Heat and Moisture, it being rais'd to this Degree of Perfection, in some Sand first moistened, and then inclosed together with the Seed, in a Glass Tube, wore all Day in the Pocket, close to the Body, and at Night, placed within a large Tin Bottle, filled with hot Water, which is a plain Demonstration that the Plant, and all that belonged to it, was actually in the Seed; that is to say, not only the young Plant, its

* *Phil. Transf.* No. 287.

Body, Root, and Fruit, but even its *Seed* also, to perpetuate the Species; as hath been before observed.

Mr. *Leeuwenhoek* comparing the *Animalcula* in *Semine Masculino*; and these Plants, computes them to be 1,000,000 times smaller than a Plant in an Orange-Kernel; and tho' we cannot make our Observations of the Growth and Increase of the said *Animalcula* from Time to Time in their Mother's Matrix; yet we may certainly conclude, that the Laws which the *wise Creator* of all Things hath prescribed to *himself*, in the *Production* both of *animate* and *inanimate* Creatures, are homogeneous and uniform; and that as the Earth is the common Matrix of Plants, so is the Fallopian Tube in most of those Animals that are formed *Ex Semine Masculino*; for as these receive their Nourishment, and increase by a String, till they are brought into the World; so are all Seeds (at least as far as we know) supported and nourished by a like String; and the Seeds thrown into the Ground, do again, by the same String, whereby they received their Increase, convey Nourishment to the Seed or Kernel.

S E C T. XI.

Of the Seeds of Venus Looking-Glass, or Corn Violets.

FIG. 458. represents one of the Seeds of *Corn-violets*; the Seed is very small, black, and shining, and to the naked Eye looks almost like a very small Flea, but through the *Microscope* appears to be covered with a tough, thick, and bright, reflecting Skin, very irregularly shrunk, and pitted, that it is almost impossible to find out two of them wrinkled alike, so great a Variety there is even in this little Seed.

S E C T. XII.

Of the Seeds of Thyme.

THESSE little Seeds, although they differ somewhat in Figure and Bulk, yet when looked at through the *Microscope*, all of them exactly resemble a dried Lemon, one of which is represented at Fig. 459. some of them are a little rounder, and of the Shape of an Orange. They have each of them a conspicuous Part, by which they are joined to their little Stalks, they are a little creased or wrinkled, as is expressed in the Figure.

S E C T. XIII.

Of the Seeds of Poppy.

Poppy Seeds, one of which is represented in Fig. 460. deserve to be taken Notice of among the other *microscopick* Seeds of *Vegetables*; both for their Smallness, Multiplicity, and Prettiness, and also for their admirable soporifick Quality, although they grow in a very large Case, yet are they so small, as not to exceed the Bulk of a very small Nitt, being not above $\frac{1}{32}$ Part of an Inch in Diameter; whereas the Seed Case oftentimes exceeds two Inches, and is therefore capable of containing near two hundred thousand of them. They are of a brownish colour'd Red, curiously Honeycomb'd all over with a pretty Variety of Net-work, or a small Kind of Embossment of very orderly rais'd Ridges.

S E C T. XIV.

Of Purflane Seed, &c.

THE Seeds of *Purflane* seems of very notable Shapes, and appear through the *Microscope* like *Porcelane* Shells, as at Fig. 461. It is coyled round in the Manner of a Spirial; at the greater End, which represents the Mouth or Orifice of the Shell, is a white, skinny, transparent Substance B, which seems to be the Place where the Stem was joined. Its whole Surface is cover'd with little Prominencies, orderly ranged in spirial Rows; one of these being cut asunder with a sharp Penknife, discovered the Shell to be of a brownish Red, but somewhat transparent, and manifested the Inside to be filled with a whitish green Pulp, the Bed wherein the seminal Principle lies *inveloped*.

Fig. 465. represents the Seed of *Ben*, it is something like a Kidney, but hath its Circumference rais'd up into double Ridges, towards which several small Ridges do in some Sort radiate from one Center.

Fig. 464. represents the Seed of *Chickweed*, this also is partly like a Kidney, and partly like a Retort, being rough cast with small Pieces, as if they were Insects with little Feet.

Fig. 463. represents the Seed of *Bellis Tanaceti Folio*. It hath two triangular Sides, and the third conical; the two first have several Ridges running to the Base, the Head triangular with one Side convex, the other two streight with a little Pinnacle in the Center.

Fig. 462. represents the Seed of *Wartworth*, or *Sun Spurge*, it is of a very complex

complex Figure, its Belly consisting of two *Planiconick* Sides, and back *Sphericonick*. The Base and Head are both flat, in the Middle of the former is a Peg, by which the Seed is fastened, and of the latter a pointed Knob. The Belly-Sides is hollowed, so as to make a flat Rim of equal Breadth; and the Hollows filled up with Bladders, like those of the parenchymous Parts of a Plant.

There are Multitudes of other *Seeds*, which imitate the Forms of divers Sorts of *Shells*; as Seed of *Scurvy-Grass*, a Kind of *Purcelane Shell*; others represent several Sorts of larger Fruits, *Sweet* and *Pot Marjoram* represent *Olives*, *Carrot-Seeds* are like a Cleft of a *Cocoa Nut Husk*. Others are like artificial Things, as *Succory Seeds* are like a Quiver of *Arrows*, the Seeds of *Aramanthus* are somewhat like an *Eye*, the Skin of the black and shrivell'd Seeds of *Onion*, are all over knobbed like a Seal Skin, and *Sorrel* has a black shining three-square Seed. It is almost endless to reckon up the several Shapes of Seeds, they being so many and so various in their Forms. I shall therefore leave them to the further Examination of the curious Observer.

The Seed or Powder of the *Fungus Purverulentus*, or *Puff-Ball*, when crushed, appears like Smoak to the naked Eye, but when examined by one of the greatest Magnifiers, is found to be infinite Numbers of little Orange colour'd Globules, somewhat transparent; in another Sort the Globules are of a darker Colour, each of them having a little Stalk or Tail, which are evidently so many minute *Puff-Balls*, * furnished with Stalks, to penetrate easily into the Ground, and the Mischiefs they do the Eyes, is probably owing to the Sharpness of these Stalks,† which prick and wound that tender Organ.

C H A P. XXXVI.

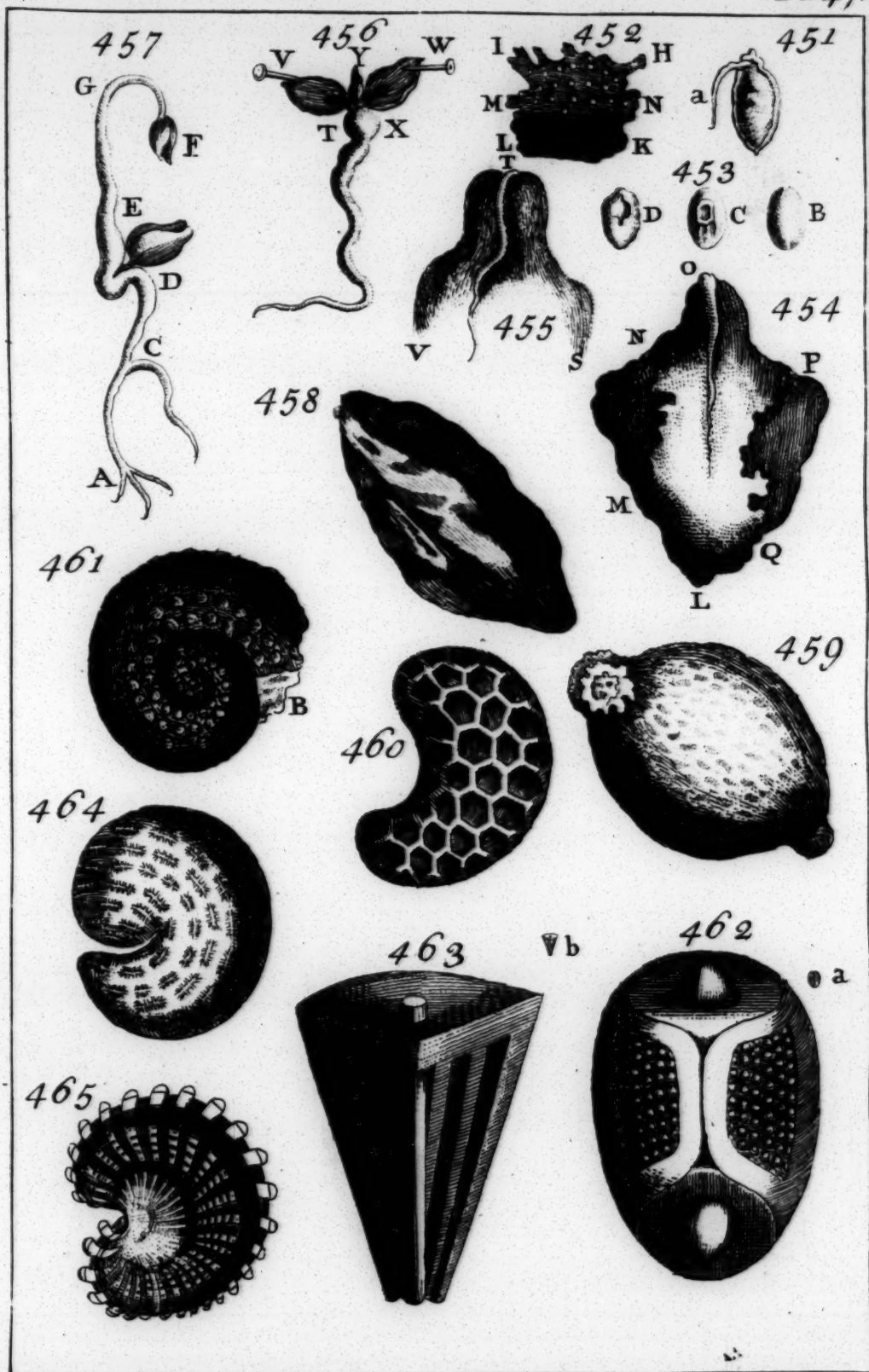
Of the Roots of Plants.

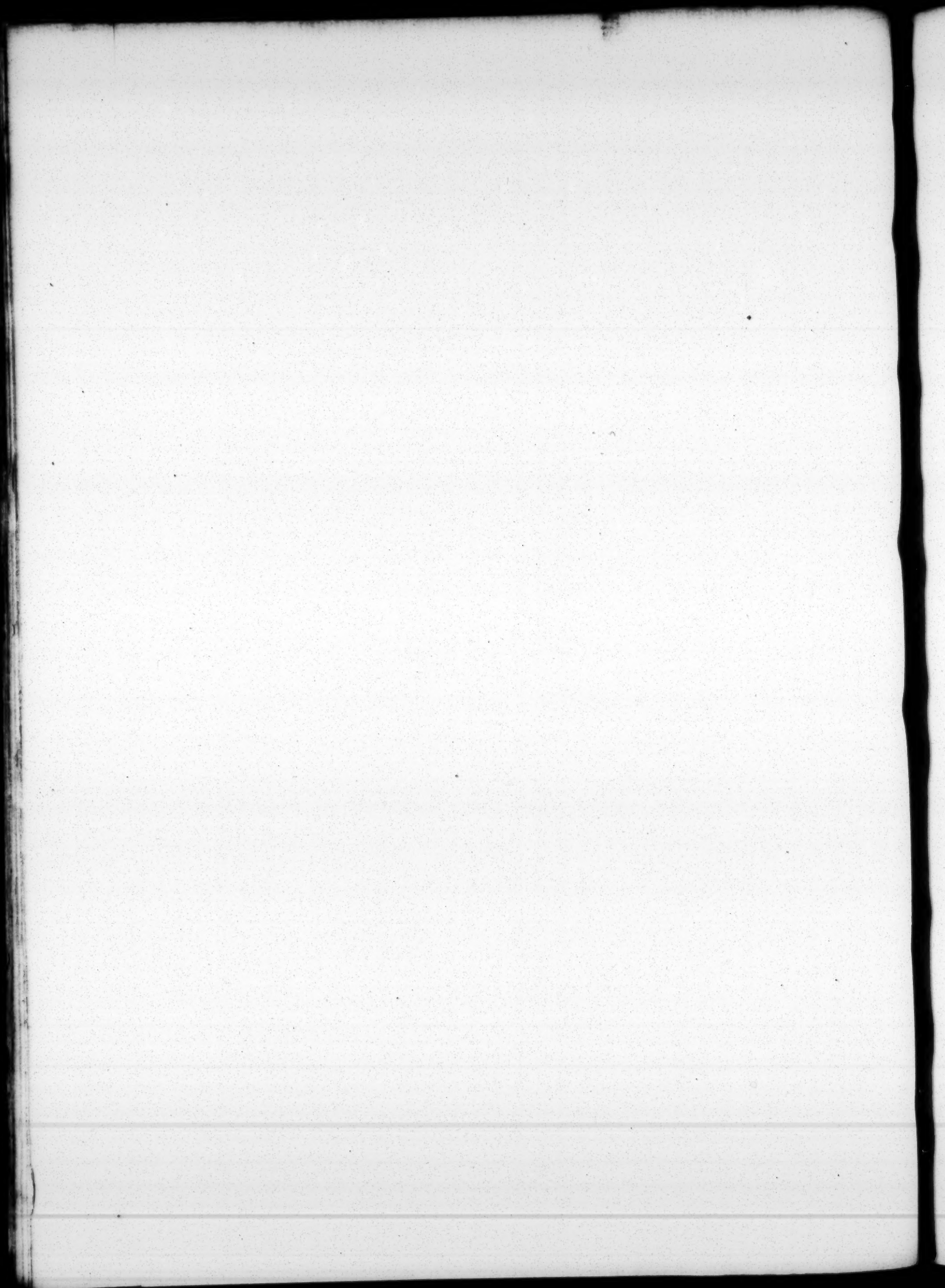
S E C T. I.

THE *Root* is that Part of a *Plant* which immediately imbibes the Juices of the Earth, and transmits them to the other Parts for Nutrition. It consists of woody Fibres, cover'd with Bark, more or less thick, and arises from a little Point in the Seed called the Radicle.

We learn by the Assistance of the *Microscope*, that Plants consist of different Parts, Vessels, &c. each of which is supposed to be the Vehicle of a different Humour, or Juice, secreted from the Mass of Sap, which is consider'd as the common Fund of them all.

* *Phil. Trans.* No. 284. † *Derham's Phys. Theo.* p. 418.





I must not here omit a curious Phenomenon in the Natural History of Plants, and that is, when the *Radicle* in sowing happens to light lowest, it is no wonder the Root should spread itself under Ground, and the Stem of the Plant rise up perpendicularly: But when the *Radicle* falls uppermost, by what Means it is that it changes its Position, to favour the Ascent of the Stem, is one of the Wonders of Vegetation.

M. Dodart first observed this Perpendicularity of Plants, and published it in an express Essay of the Affectation of Perpendicularity, observable in the Stems or Stalks of Plants, &c.

The Matter of Fact is, that though almost all Plants rise a little crooked; yet the Stems shoot up *perpendicularly*, and the Roots sink down *perpendicularly*; even such as by the Declivity of the Soil come out inclined, or are diverted out of the Perpendicular by any violent Means; again redress or strengthen themselves, and recover their Perpendicularity, by making a second or contrary Bend, or Elbow, without rectifying the first.

A common Eye looks on this Affectation, without any Surprise; but a Man, who knows what a Plant is, and how formed, finds it a Subject of Astonishment.

It has been before shewn, that each Seed contains a little Plant, already formed, needing nothing but to be unfolded; the little Plant has its little Root and Pulp, which is generally separable into two Lobes, and is the Foundation of the first Food the Plantule draws by its Root, when it begins to *germinate*.

If a Seed in the Earth be so disposed, as that the Root of the little Plant be turned downwards, and Stem upwards, and even *perpendicularly* upwards; it is easy to conceive, that the little Plant coming to unfold itself, its Stalk and Root need only follow the Direction they have to grow perpendicularly. But,

It is very well known, the Seeds of all Plants, whether sown of themselves, or by the Help of Man, fall into the Ground at random; and among an infinite Number of Situations, with respect to the Stalk of their Plant, the *perpendicular* Direction upwards is but one.

It is therefore necessary that the Stalk redress or rectify itself in all the other Situations, in order to find its Way out of the Ground: But what Force is it that effects this Change, which is certainly a violent Action? Is it, that the Stalk finding a less Load of Earth above it, goes naturally that Way where it finds the least Obstacle; were it so, the little Root when it happens to be uppermost, must for the same Reason follow the same Direction, and mount on high.

Therefore *M. Dodart*, supposes the Fibres of the Stalks are of such a Nature, as to contract and shorten by the Sun's Heat, and lengthen out by the Moisture of the Earth; and on the contrary, that the Fibres of the

Roots contract by the Moisture of the Earth, and lengthen by the Heat of the Sun.

Then when the Root of the Plantule is uppermost, the Fibres which compose one of the Branches of the Root, are not equally exposed to the Moisture of the Earth; the lower Part is more exposed than the upper, which must therefore contract the most; this Contraction is again promoted by the lengthening of the upper, whereon the Sun acts with the greatest Force; consequently this Branch of the Root must recoil towards the Earth, and insinuating thro' the Pores thereof, get under the Bulb, &c.

By inverting this reasoning, it will appear, how the Stalk comes to get uppermost.

In a Word, we may imagine, that the Earth attracts the Root to itself, and that the Sun contributes to its Descent; and, on the contrary, that the Sun attracts the Stem, and the Earth in some Measure sends it towards the same. Again,

M. *de la Hire* imagines, that the Root draws a coarser and heavier Juice, and the Stem and its Branches a more volatile one; which Difference of Juices, supposes larger Pores in the Roots than in the Stalks; therefore in the Plantule we may conceive a Point of Separation; such, that all one Side of the Root shall be unfolded by the grosser Juices, and all the other Side by the more subtle ones.

If now the *Plantule* be inverted when its Parts begin to unfold, the Juices which enter the Root being coarsest, when they have enlarged the Pores to admit Juices of a determinate Weight, those Juices pressing the Root more and more, will drive it downwards, and this the more as the Root is more extended or enlarged; for the Point of Separation, being conceived as the fix'd Point of a Lever, they will act by the longer Arm. At the same Time the volatile Juices having penetrated the Stalk, will tend to give a Direction from below upwards, and by Reason of the Lever, will give it more and more every Day till it be perfectly erect.

Mr. *Astruc* accounts for Perpendicularity of the Stems, and their redressing themselves on these two Principals.

First, that the nutritious Juice arises from the Circumference of the Plant, and terminates in the Pith. Second, That Fluids contain'd in Tubes, either parallel or oblique to the Horizon, gravitate on the lower Part of the Tubes, and not at all on the upper.

Whence it easily follows, that in a Plant posited either obliquely or parallel to the Horizon; the nutritious Juice will act more on the lower Part of the Canals than on the upper; and by this Means insinuate more into the Canals communicating therewith, and be collected more copiously therein; thus the Parts on the lower Side will receive more Accretion, and be more nourished than those on the upper; the Consequences whereof must be, that the Extremity of the Plant will be obliged to bend upwards.

The

The same Principle brings the Seed into its due Situation at first; in a *Bean* planted upside down, the Plume and Radicle are easily perceived with the naked Eye, to shoot at first directly for about an Inch; but thenceforward they begin to bend, the one downwards, and the other upwards, as in the Example of the Orange Seed, Fig. 457; the like is seen in a Heap of *Barley* to be made *Malt*, in a Quantity of *Acorns* laid to sprout in a moist Place, &c. each Grain of *Barley* in the first Case, and each *Acorn* in the second hath a different Situation, and yet all the Sprouts tend directly upwards, and the Roots downwards, and the Curvity or Bend they make, is greater or less as their Situation approaches more or less, to the Direction wherein no Curvature at all would be necessary. Now two such opposite Motions cannot arise without supposing some considerable Difference between the two Parts; the only one we know of, is, that the *Plume* is fed by a Juice, imported to it by Tubes parallel to its Sides; whereas the Radicle imbibes its Nourishment at all the Pores in its Surface. As oft therefore as the Plume is either parallel or inclined to the Horizon, the nutritious Juice feeding the lower Parts more than the upper, will determine its Extremes to turn upwards, for the Reason already assigned. On the contrary, when the Radicle is in the like Situation, the nutritious Juice penetrating more copiously through the upper Part than the under; there will be a greater Accretion of the former than the latter; and consequently the Radicle will be bent downwards: And this mutual Curvity of the Plume and Radicle must continue, till such Time as their Sides are nourished alike, which cannot be till they are perpendicular*.

Roots are generally distinguished by their Figures, some being entire, as *Liquorice*; parted, as *St. Johnwort*; some parted at Bottom, as most Roots; others at Top, as *Dandelion*, &c. some parted and ramified, as *Comfrey*; others having divers Strings issuing from one Head, as *Crowfoot*; some strait as *Radish*, crooked as *Bistort*, smooth as *Bugloss*, stringy all round as *Columbine*; some thick as *Rhubarb*, slender as the *Vine*, long as *Fennel*, short as *Turnep*, &c. &c.

The Motions of Roots are sometimes perpendicular, as *Parsnip*, level as *Hops*, *Ammi*, *Cinquefoil*, &c.

There is a kind of wreathing or twisting in the Vessels of some when the Bark is stripped off, in *Carduus*, *Sonchus*, &c. in which may be sometimes seen two or three Circumvolutions.

But the most remarkable of all *Roots* are such as are annually renewed or repaired out of the Trunk or Stalk itself, as *Arum*, *Rape-Crowfoot*, *Valerian*, *Brownwort*, *Bearsfoot*, *Tansy*, *Lychnis*, *Sapier*, *Primrose*, *Ammi*, *Avens*, *Wood-Sorrel*, *Iris*, and others; that is to say, the Basis of the Stalk continually and by insensible Degrees, descending below the Surface of the Earth, and hiding itself therein, is both in Nature, Place and Office changed into

* *Men. d. l. Acad. Roy. des Science, n. 1708.*

a Root. So in *Brownwort* the Basis of the Stalk sinking down by Degrees till it lies under Ground, becomes the upper Part of the Root; and continuing still to sink, the next Year becomes the lower Part, and the next after that rots away, * a new Addition being yearly made out of the Stalk, as the older Parts annually rot away.

In a Dissection of the *Root* we shall first find the *Skin*, next the *Cortical*, which when thin is commonly called the *Bark*; next within this are the woody *Fibres*, which together with all its Parts, are visible in a Circle; its Pores being nothing near so numerous as that of the *Cortical*, but in some more open than in others, as may be seen on cutting a very thin transverse Slice of the Branch of a Tree, and holding it against the Light, or placing it before the *Microscope*. In *Currant* and *Goosberry-Trees* it is less conspicuous than in *Oak* or *Plumbs*, in *Damfins* it is more, and in *Elder* and *Vines* more; the cortical Body doth not only surround the Wood, but is as it were wedged into it in many Places, and is even inserted therein as far as the Pith, and appears in a transverse Section of a Root like Lines drawn from the Center to the Circumference.

Fig. 466. represents a transverse Slice of the Root of *Asparagus*, and Fig. 467, exhibits a *microscopic* Picture of a Piece thereof cut out at a b, in which

A B shews the Skin.	inner Edge of the Bark.
A B C D the Bark, or all that Part analogous to it.	E F G H the Wood in which the black Spots shew the Air Vessels.
C D E F the Lympheducts on the	G H I the Pith.

Fig. 468. is a transverse Slice of the Root of *Mallows*. Fig. 469. represents a Piece thereof, which was cut out at c d, as it appeared before the *Microscope*; in which

A B C D shews the Skin.	E F G H the common Lympheducts.
C D E F the Bark, or all that Part of the Root which answers to it, in which the round Spots are the Muciducts.	G H I K the pithy Part of the Root. I K L more Lympheducts, in both which the black Holes are the Air the Air Vessels.

Fig. 470. represents a Slice of a *Vine Root* cut transversly, out of which at e f was cut a small Piece, which when placed before the *Microscope* appeared as represented by Fig. 471. wherein

A B shews the Skin.	small are the Air Vessels.
A B C D the Bark.	E F parenchymous Insertions between the Parcels of Wood.
L S Parcels of Sap Vessels.	G G others within them.
L I Parcels of Wood in which the darker shaded Circles great and	

* Grew. *Anat. of Plants*, p. 59.

At Fig. 472. is seen a transverse Slice of a *Horse Radish* Root, and at a b the Place from whence a Gore was cut, which is represented as it appeared in the *Microscope* by Fig. 473. whereof

AB is the Skin.

ABCD the Bark.

CDEFGHI the Sap Vessels in Form of a Glory.

CDKL the Wood in which the

darker Circles are the Air Vessels.

KL MN a Ring of more Sap Vessels.

MNO the Pith.

Fig. 474. exhibits a transverse Section of *Buglose Root*, from which at c d was taken a small Piece, that when magnified appeared as Fig. 475. in which

AB is the Skin.

ABCD the Bark.

ABEF the Bladders in the outer Part of the Bark; they are figured somewhat oblong, and are ranged in Circles.

E FCD the inner Part of the Bark in which the Bladders are ranged in

curved Arches.

CDGH a Ring of Sap Vessels,

II a parenchymous Insertion, of which there are several in the whole Section.

LKKL the Wood in which the dark Spots are the Air Vessels.

KKM the Pith.

SECTION II.

Of the Skin of Roots.

THE outer Part of all *Roots* is the *Skin*, which in *Skerrits* is white, yellow in *Dock*, red in *Potatoes*, brown in *Lovage*, black in *Bugloss*, &c. their Surface is sometimes smooth, as in *Horse radish*, rough, as in *Scorzonera*. The Skins of the several Shells of a *Tulip-Root* fresh taken up, appear to be perforated with a Number of small Holes. This Skin is very thin in *Parsnip*, thicker in *Bugloss*, very thick in *Iris*, opake in some as the *Thistle*, and transparent in others, as the *Madder*.

Every *Root* hath two kinds of Skin, one of the same Age with the other Parts, and the other succeeding in the Place of the former; as in *Dandelion*, the old Skin seems to be that Part which composed the cortical Body the Year before, which by the Generation of a new Ring next the Wood, is now thrust outward, and shrunk up into a Skin as at AB; in an *Horse-radish* Root, Fig. 473. or at AB in a *Bugloss* Root, Fig. 475. as far as the Bladders in the former, and Vessels in the latter, are radiated; the cortical Body seems to shrivel up into a new Skin, as the old ones fall off, and probably the whole Body of the perpendicular Roots, except the woody Fibre in the Center, becomes the second Skin, as in *Asparagus*, Fig. 467.

This

This Skin is made up of two Kinds of Bodies, one parenchymous, generally composed of exceeding small Cells or Bladders, which are plainly visible, if viewed through a *Microscope*, and appear as in Fig. 467. which represents a transverse Piece of the Root of *Asparagus* magnified; these Bladders are of different Sizes, being larger in *Bugloss* than in *Asparagus*, &c.

The other Part of this Skin is composed of tubular Wood-Vessels, intermix'd with the Bladders before-mention'd.

If a *Root* be cut transversely, and laid by for some Time, all the Parts where there are no Vessels will shrink below the Surface of the cut End; but the Vessels will all retain the same Length, at which Time they may be examined by the *Microscope*.

Of the Bark of Roots.

THE *Bark* is situate just within the Skin, in some Roots it is yellow, as in *Dock*, red in *Bistort*, but in most white, in some it is very thin, and in others it makes the greatest Part of the Root, the thinnest and thickest being all analogous.

It is exceeding porous both in Length and Breadth, as appears from its shrinking up equally both Ways, and dilating to its former Size on being soaked in Water. All this is apparent to the naked Eye; but the *Microscope* confirms the Truth thereof, by shewing that these Pores are an infinite Number of little Cells or Bladders, sometimes running in Ranks both the Length and Cross-ways of the Root, as at A B C D in *Bugloss*. Fig. 475. it may be seen both in a transverse and upright Section, and always best after the Pieces so cut hath lain by some Time to dry.

This parenchymous Part is of an uniform Texture in many Roots, and diversified in as many others; the Bladders, though very regular, yet differ in Shape, Size and Situation; in some Places like white Rays, streaming from the inner Edge thereof outwards to the Circumference of the Bark, as is apparent in a transverse Section of *Lovage*, *Melilot*, *Parsnip*, &c. continuing in direct Lines the whole Length of the Root.

The *Bark*, as before observed, is intermixed with a few lignous Vessels, which are apparent in most Roots in the Resemblance of Threads. These tubular Threads do not run in direct Lines, but are frequently braced together in the Form of Network, as is apparent if the Bark be stripped off, and a Piece of it examined by the *Microscope*.

In *Parsnips* these Vessels yield a thin Lympha. It is certain that this clear Sap ascends only in these Vessels, because no Liquor will do the like from any parenchymous Part; sometimes they yield a thick mucilaginous Lympha as *Comfrey*; oftentimes these succiferous Vessels yield a milky or white Sap, and sometimes yellow, as in *Sonchus*, and most cichoraceous Plants; in *Angelica*,

gelica, and most umbelliferous; in *Burdock* and divers Thistles; in *Scorzonera*, common Bells, and many other Plants, not commonly taken Notice of to be milky. These milky Saps, although of different Colours, Thickness, and other Qualities, agree in being more oily than any of the lymphous Saps; for the Mixture of the oily Parts, with some other limpid Liquor, causes them to be of a milky *, or other opaque Colour. In the same Manner as common Oil, and a strong Liquament of Tartar, shook in a Bottle, become white.

Sometimes the Oil will separate, as is observable on cutting a *Fennel* Root transversely, after it hath lain some Days out of the Ground. The same Vessels, which before yielded Milk, will now yeild Oil.

All Gums and Balsams are likewise the Contents of these Vessels, for these and Milks are nearly a-kin. The Milk of *Fennel* standing some time, turns to a clear Balsam, of *Scorzonera*; *Dandelion*, and others; to a Gum. In the dried Root of *Angelica*, when split, the Milk † is seen in Clods, in the Continuation of these Vessels, condensed into an hard shining Rosin. The Root *Helenium* cut transversely, presently yields a Balsam of a Citron Colour, so called because it will not dissolve in Water. The Root of common *Wormwood* yields a true Balsam, with all the defining Properties of a Terebinth; the Roots of *Trachelium* and *Enula*, yield both a Lympha and a Citron Balsam; and *Wormwood* both a Lympha and a Terebinth § at the same Time. It is doubtful whether all Roots have Lympha Ducts, but probably they have, and for the most Part standing in a Ring, at the inner Verge of the Bark.

The Situation of these Vessels are very curious, if viewed in a transverse Section of the Root; sometimes they only form a Ring at the inner Edge of the Bark, as at E F, in *Asparagus*, Fig. 467. in which Position they are in most, if not all Roots; in some they stand in Rays, as *Borage*, or *Peripherial*, as in *Celandine*. These vascular Rays are extended in some towards the Circumference of the Bark, about half Way, as between C D E F, in Bugloss, Fig. 475. in all *Docks* and *Sorrels*, about $\frac{3}{4}$ ths of the Thickness of the Bark toward the Circumference, several of them are also arched thereabout. In all, or many *Trefoils*, and of the leguminous Kind, only one Third of the Bark. In the umbelliferous, they are situate between the diametrical Portions of the Parenchyma. In the *Microscope* they all of them appear to be real Circles; and in a transverse Section, when the Milk has been licked off with the Tongue, till no more will rise. They may also be soaked in Water, after which the Position of the Milk Vessels will be visible; in some Roots they run more parallel, and keep asunder, as in *Monks-hood*, and join towards the Circumference of the Bark, in *Eryngo*. They terminate more circular, in *Briony* angular, or in the Form of a

* *Grew. An. Plant. p. 67.* † *Ibid. p. 67.* § *Ibid. p. 68.*

Glory, as will appear also on viewing an *Horse Radish Root*, C D E F G H I, Fig. 473. in the *Microscope*. In some almost entire Circles, as in *Dandelion*; in others composed of short Chords; in some these Specks are so exceeding small, that to the naked Eye they seem continued Rings, but when viewed in the *Microscope*, are distinct Vessels, as in *Marsh-Mallows*, and *Liquorice*. In *Marsh-Mallows* the Lymphæducts appear in Rays, and the Lacteals in Rings, Fig. 469. In *Dandelion* they appear to the naked Eye like numerous Rings, but when viewed through the *Microscope*, are found to consist of very many small Rays, streaming from the inner Verge of the *Bark*, a-cross three or four of the smaller Rings.

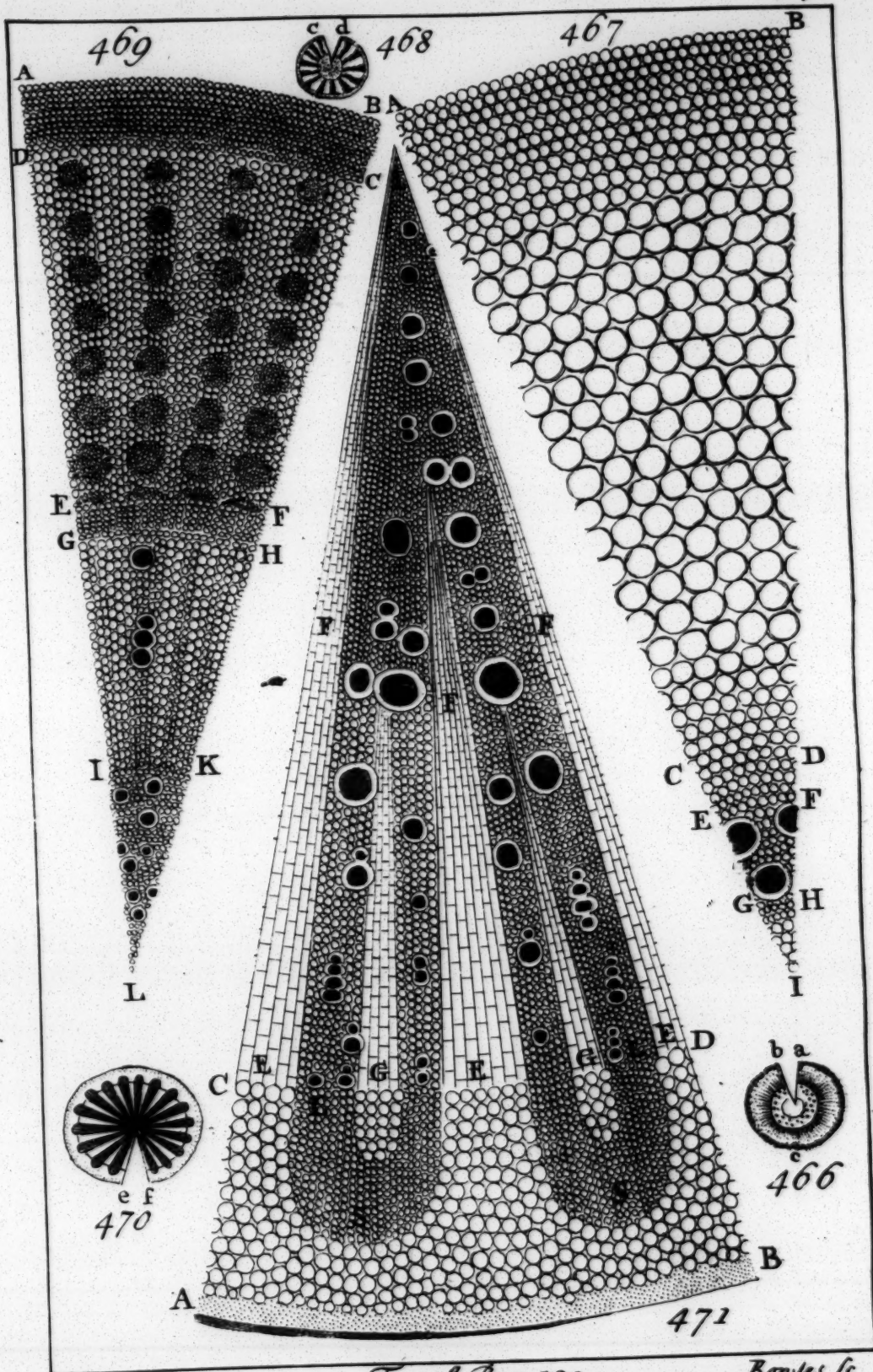
S E C T. III.

Of the Wood of Roots.

THAT Portion of the *Root*, which is contiguous to, and within the *Bark*; in *Trees*, and shrubby *Plants*, is the *Wood*, which consists of the *Parenchyma* and *lignous Substance*. The first of which is of the same Nature with that of the *Bark*. The Position of its several Parts are mostly diametrical, running between the *lignous Parts*, from the Circumference towards the Center of the *Root*, and all together constitute that which is before called the *Insertment*. These *Insertments* are most observable in the *Roots* of many *Herbs*, as *Comfrey*, which exhibits a good Notion of all other, as well *Trees* as *Herbs*; sometimes this parenchymous Body is disposed into Rings, as in *Fennel*. In most woody *Roots*, they stream between the *Pith* and *Bark*, like so many small *Rays*. In some *Roots* they continue to the Center, as *Columbine*, in others not, as *Parfnip*; and sometimes different in the same *Root*, as E F in the *Vine*, Fig. 471. They are composed of many small *Bladders*, as in the *Bark*, but generally smaller. Their Shape usually round, but sometimes oblong and oval, as in *Borage*, or oblong and square, as in the *Vine*.

The *lignous Part* also consists of two Kinds of Bodies, *succiferous*, or *lignous*, and *Air Vessels*. The *lignous* are of the Nature with those of the *Bark*, and in a transverse Section of the *Root*, emit a *Liquor* as those do. These *Vessels* are no where interwove or braced together, but continue from one End of the *Root* to the other.

The Position of both these Kind of *Vessels* is various, the *succiferous* or *lignous* are sometimes situate in diametrical Lines, as in the *Vine*, Fig. 471. and most *Trees*, sometimes opposite to the *Areal*, as in *Beet*, &c.





S E C T. IV.
Of the Pith of Roots.

Within the woody Part, is the *Pith* which is not common to all Roots, for some have none, as *Nicotian*, *Stramoniam*, and others. The *Pith*, for the most Part, especially in Trees, is a simple Body, yet like the Bark it is compounded, some succiferous Vessels being mixed with it, as in *Jerusalem Artichoke*, *Horse Radish*, &c. many Roots that have no Pith at their lower Part, have one at the Top, as *Columbine*, *Lovage*, &c. Their Contexture by the *Microscope*, appears to be of the same general Kind in all Plants, both in the Parenchyma of the Bark, in the Insertment or diametrical Portions, and in the Pith, all being composed of *Bladders*, which are of very different Sizes, seldom less than those of the Bark, as in *Asparagus*, Fig. 467. but generally much bigger, as in *Horse Radish*, Fig. 473. their Position seldom varies, but is uniform in a transverse Section of all Parts of the Root piled up evenly one over another. In an upright Section they seem to run in direct Trains, length-ways; they are for the most Part orbicular, though in the larger Roots somewhat angular. On observing these Bladders with the *Microscope*, their Sides will be found to consist of several Ranks of exceeding small Fibres, lying for the most Part evenly one over another, from the Bottom to the Top of every Bladder, and running a-cross also from one Bladder to another. If the *Pith* be cut with a sharp Razor, or Penknife, and so applied to the *Microscope*, they will be seen distinctly.

All Plants exhibit this Spectacle, but those best with the largest Bladders; nor the same *Pith* so well in any other Condition, as when dry; because then the Sap being voided, the Spaces between the Fibres, and the Fibres themselves are more distinctly seen. Yet it must not be dried after cutting, because its several Parts will thereupon coincide and become deformed, but to be chosen while the Plant is growing, at which Time it may be often found dry and not deformed; as in the Trunks of *common Thistle*, *Jerusalem Artichoke*, &c. cut off the white Bottoms of the Bladders of a *Bulrush* transversely, and they will appear like a curious Piece of Needle-work. The whole Body of a *Root* therefore consists of Vessels and Fibres, and probably these Fibres themselves are tubular.

If you take the Roots of *Vine*, *Fennel*, *Dandelion*, *Plumb-tree*, *Elder*, *Willow*, &c. and lay them for some Time to dry, then cut off a thin Slice of each transversely, and place it before the *Microscope*, by pinching one Edge thereof between the Nippers, the Light will then be trajected through the Perforations of all the Vessels both great and small, they are scarce ever visible in the fresh Slices of these Roots.

A clear and elegant Sight of the Fibres which compose the Air Vessels, may be obtained by splitting a *Vine Root*, or a Piece of *Oak*, and may be seen in the Side of the greater Air Vessels, in the Resemblance of Needle-Work; the Spiration of the Fibres may be better observed in the *Trunk* than in the *Root*, and best in *young Plants*, but not so well by cutting as splitting, or by tearing off some small Piece, through which they run; their Confirmation being by this Means not spoiled.

But in the Leaves or tender Stalks of all such Plants as shew upon breaking, a kind of Down or Wool; they may be seen drawn out, and that sometimes to the naked Eye. This Wool being nothing else but a certain Number of Fibres drawn out of their spiral Position, appearing more or less in the Leaves and other Parts of most Plants, as in the *Vine*, *Scabious*, &c. in the *Scales* of a *Squid* they are so easily separable, as to shew the Plate or Zone into which the *Air Vessels* are usually resolved, which is not one single Piece, but made up of several round Fibres, running parallel, and knit together by other smaller ones transversely in the Form of a Zone.

C H A P. XXXVII.

Of the Trunks of Trees.

S E C T. I.

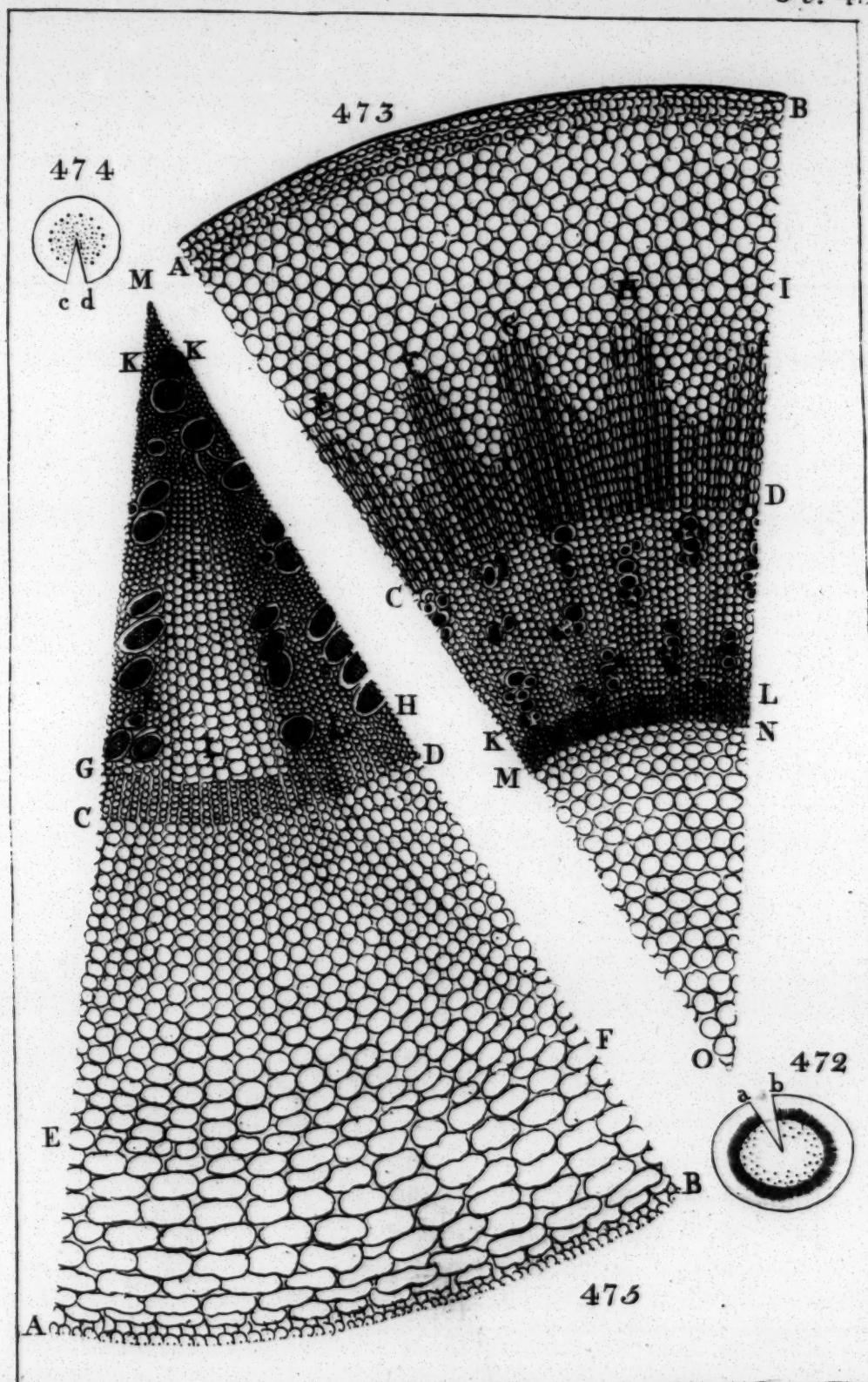
THE *Trunk* comes next under Consideration, which consists of the *Bark*, the *Wood*, the *Insertions* or *Veins*, and the *Pith*.

The cross Shootings of the Wood in Trunks of several Years Growth appear in Rings, so that we may judge by the Number of Rings of how many Years * Growth the Tree is; in each of these Rings is one Circle of large open Pipes, but the fewer of these the stronger the Timber.

The Pores of the Wood in well-grown Timber are very conspicuous both in an upright and transverse Section thereof.

The lignous Body in the Trunks of Herbs are extremely visible in the *Microscope*, each Fibre thereof being perforated with 30, 50, 100, &c. Pores, as may be seen in a magnified Piece of Burdock, Fig. 477. and although each Fibre appears to the naked Eye to be but one, yet when magnified we plainly find them to be composed of a Number of Fibres, or rather hollow Tubes joined together, so that what we call the woody Part of a Tree, notwithstanding all its Solidity, is nothing else but a Cluster of innumerable and extraordinary small vascular Fibres; some of which rise from the Root upwards, and are disposed in Form of a Circle, and the others which Dr. Grew calls *Insertions*, tend horizontally from the Surface to the

* *Phi. Transf.* No. 213.





Center, in such a Manner as to cross each other, and are interwove like the Threads of a Weaver's Web.

These *Insertions* are visible on sawing Trees Lengthwise, and shaving from thence very thin Slices. They are also discernable at their Entrance into the Wood on stripping off the *Bark*.

As the Pores or Vessels are greater or less, so are also the Insertions, to the naked Eye, the largest only are discernable; but by the Help of the *Microscope* they appear very numerous.

The Insertions in the Trunk are visible in a transverse Section, and are disposed in even Lines or Rows throughout its whole Breadth; they are represented as they appear in the Root of a *Vine*, when viewed through a *Microscope*, by E F, Fig. 471.

The Pores of the Pith are mostly observable in the *Trunk*, being larger than in the Root; and through a *Microscope* appear like so many Bubbles or Bladders, as in a Piece of *Burdock*, Fig. 477.

In the Piths of many Roots and Plants, some of the larger Pores or Bladders have smaller ones within them, some of which are divided with cross Membranes, and between their several Sides other smaller Bladders are inserted, in orderly Ranks Length-wise.

What Dr. *Grew* calls *Fibres* and *Insertments*, or the lignous Body interwoven with that which he takes to be the cortical, that is the several Distinctions of the Grain, are called by Mr. *Lister* Veins,* that is, such Ducts as seem to contain and carry in them their noblest Juices, analogous to human Veins. Mr. *Lister* makes it appear, that these Vessels are not the Pores of the lignous Body, from a transverse Section of *Angelica Sylvestris magna vulgarior*; the Veins there clearly discovering themselves to be distinct from the Fibres, observable in the Parenchyma of the same cortical Body, the milky Juices always rising on the Side, and not in any Fibre. Also in a like Incision of *Burdock*, in *June* the Juice springs on each Side the Radii of the woody Circle, that is, in the cortical Body and Pith only; again where there is no Pith none of this Juice is observed.

In a transverse Cut of a Leaf it is observable, 1. That these Veins accompany the Ribs and Nerves. 2. That the middle Fibre or Nerve seems to yield one big Drop of a milky Juice springing as it were from one Vein, yet by the *Microscope* it is plain there are many Veins, to the making up of that Drop. 3. That if a Fibre or Nerve be carefully taken out of the Leaf, the Veins will appear therein like so many Pipes running along the Nerve, and yet these numerous Veins are all of an equal Bigness.

It is observable in the Motion of these Juices, that the milky Juice always moves and springs briskly upon the opening of a Vein, † the limpid Sap only at certain Seasons.

* *Phil. Transf.* No. 79. † *Ibid.* No. 90.

Dr. *Grew* assigns the Offices of the several Vessels, viz. those placed on the inner Verge of the Bark, he calls *Lymphæducts*, and supposes them destined for the Conveyance of the most watry Liquor; these Mr. *Bradley* calls the *new forming Vessels*, which are annually produced, and help to increase the Bulk of the Tree.

Those in the Middle of the Bark Dr. *Grew* calls *lactiferous* or *resiniferous* Vessels: Their Use, according to *Bradley*, is to return the superfluous Sap: These Vessels *Grew* observes, are the principal Viscera of Plants; and adds, that as the Viscera of Animals are but Vessels conglomerated; so the Vessels of a Plant are Viscera drawn out at length, all which will be easily understood by an Inspection of the following Figures.

Fig. 476. represents a small Piece cut out of a *walking Cane*, as it appeared in the Microscope. A B E F shews a transverse Section thereof, wherein are seen Clusters of Air Vessels surrounded with Rings of sap Vessels, and at A B C D the Pores in the outside Skin or Bark of the Cane are plainly visible.

Fig. 477. represents a magnified Piece of the Stalk of Burdock cut transversely and down the Side.

Fig. 478. exhibits a Piece cut out of a Branch of *Pine*, wherein at A B C D is seen the Bark Side-ways, and at A B E E a transverse Section thereof, through which the Turpentine Vessels run Lengthwise. G H represents one of them cut down the Middle to shew the Inside of it, and another is seen intire at I K.

Fig. 479. represents the Milk Vessels in the Bark of *Sumach*, in the same Manner as the Turpentine Vessels are represented in the foregoing Figure, and are expressed by the same Letters also.

Fig. 480. represents Part of a *Vine Branch* cut transversely; and Fig. 481. a Piece cut out of the same at a b, as it appeared in the Microscope; whereof A B C D shews the Skin Length-ways. At A B E F is seen a transverse Section of the Wood and Air Vessels, and between G H and I K part of the Wood and Bark is taken away to shew the same Lengthwise.

Fig. 482. a, is a transverse Section of an *Apple Branch*, in which the several Circles of Wood that shew of how many Years Growth the Tree is, are visible to the naked Eye. Fig. 482. b, represents a Gore cut out of the aforesaid Slice at a b, as it appeared in the Microscope; in which

A B represents the Skin.

A B C D the Bark.

H I spiral sap Vessels in arched Parcels.

O O the common sap Vessels which begin to turn into Wood.

C D E F the Wood of three Years Growth.

K L M N one Year's Growth, in which the dark Spots represent the Air Vessels.

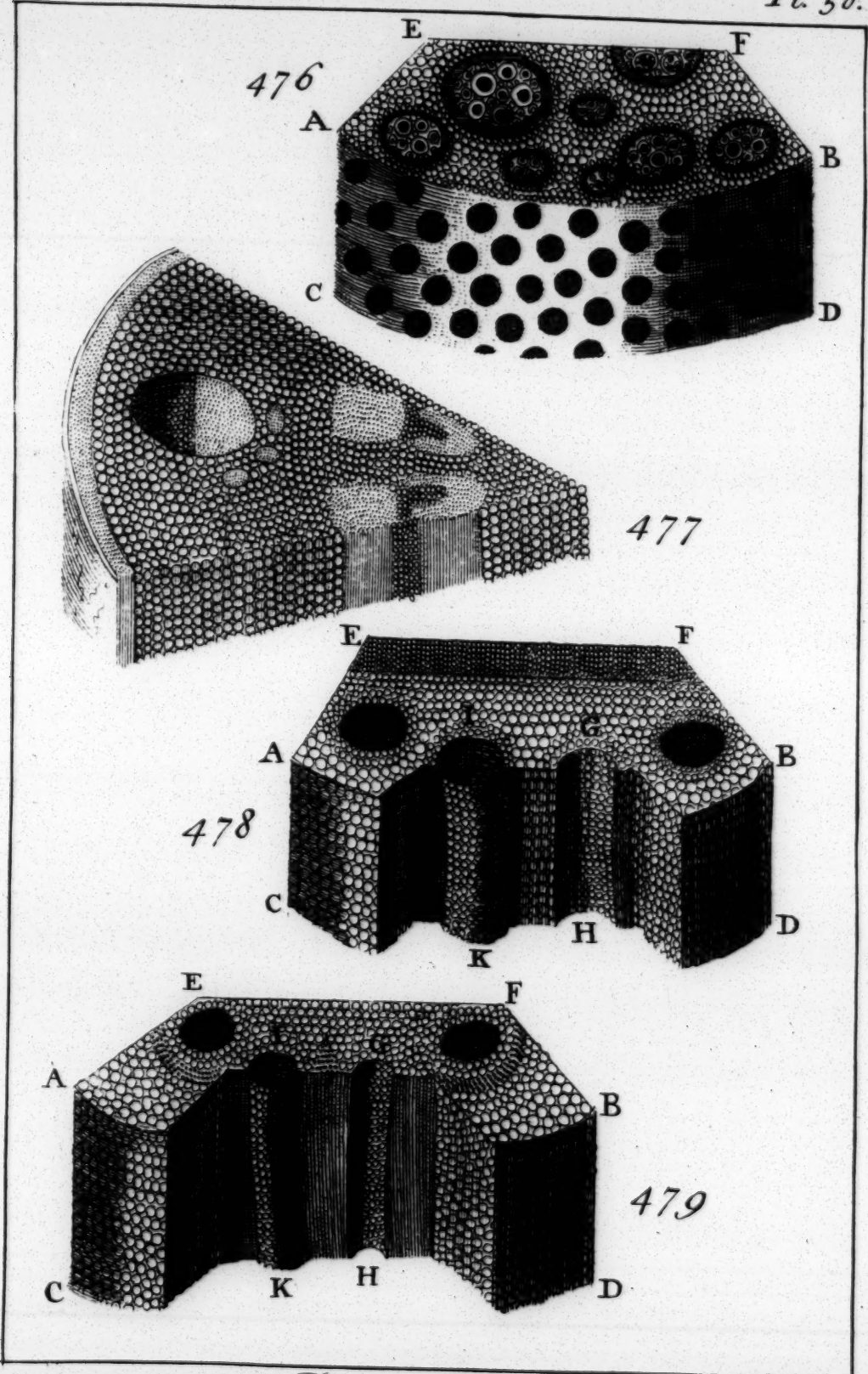
g g g the true Wood.

P P the Insertions.

E F other sap Vessels.

E F G the Pith.

Fig.





Of the Trunks of Trees.

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Fig. 483. shews a transverse Slice of a Hazel Branch, and Fig. 484 represents a Piece thereof, which was cut out at c d, as it appeared when placed in the *Microscope*.

AB the Skin.

ABCD the Bark.

QQQ the simple Parenchyma.

HI a Ring of special Vessels.

PP common sap Vessels.

CDEF the Wood of three Years Growth.

KLMN one Years Growth.

XXX great Infections.

PO lesser between them, the black Parcels between these Infections are the Wood, which is composed of minute Tubes (although it is here represented in a Shade) in which the dark Spots are the Air Vessels.

EFG the Pith.

Fig. 485. exhibits a transverse Slice of a *Walnut Branch*, and Fig. 486. a *microscopick* Picture of a Gore thereof cut out from e f, in which

AB is the Skin.

ABCD the Bark.

RR the Parenchyma.

HRI two Rings of special sap Vessels.

DC common Lympheducts.

DCEF the Wood of four Years Growth.

ddd the true Wood.

KLMN one Year's Growth.

Qd, Qd, part thereof whiter than the rest, by the Mixture of sap Vessels, which are represented by the transverse Lines.

MN the great Air Vessels.

ce, ce Parcels of lesser ones.

EF a Ring of other sap Vessels.

EFG the Pith.

At Fig. 487. is seen a Slice of a Branch of *Pine* cut transversly, and at Fig. 488. a magnified Piece of the same cut out from g h.

ABCD the Bark.

MMM the Parenchyma.

DLC the Lympheducts.

HH Turpentine Vessels.

DCEF the Wood in which the

white Spaces tending to the Center shew the Infections.

EFG the Pith, the larger Holes both in the Wood and Pith are more Turpentine Vessels.

Fig. 489. represents a transverse Section of a *Wormwood-Stalk*, from whence a Piece i k was cut, which is exhibited as it appeared in the *Microscope*, by Fig. 490. whereof

ABCD is the Bark.

AMB the Parenchyma.

HMI Balsamic Vessels.

KL another Sort of sap Vessels in Parcels.

KLCD Lympheducts.

DCEF the Wood in which the dark Spots are the Air Vessels.

MM the Infections.

R another balsamic Vessel.

EFG the Pith.

Fig. 491. is a transverse Section of a *Thistle-Stalk*, out of which at l m was cut a Piece, which is seen as it appeared in the *Microscope* at Fig. 492.

ABCD

ABCD the Bark.

HI the Parenchyma.

ee a Sort of sap Vessels.

aa another Sort.

cc Milk Vessels.

DCE F the Wood.

V V the Air Vessels.

tt more Lymphæducts.

ff mere Milk Vessels.

at Insertions.

EFG the Pith composed of angular Bladders, Bladders of Threads, and Threads of single Fibres.

Fig. 493. shews a transverse Section of *Sumach Stalk*, and Fig. 494 a magnified Gore thereof, which was cut out at n o.

ABaa the hairy Skin.

ABCD the Bark.

HWI the Parenchyma.

DMC the common Lymphæducts.

KML three Milk Vessels.

HI another Sort of Lymphæducts. arched over the Milk Vessels.

XX seems to be a third Sort of

Lymphæducts.

DC EF the Wood.

the white Rays tending from M to M are the Insertions.

YY the true Wood in which the dark Spots are Air Vessels.

EF a Ring of Lymphæducts.

EFG the Pith.

Fig. 495. represents part of a *Vine Branch* cut transversely at ABG, and at ABC, and also split half way down the Middle at G G B B, whereof

ABAB is the Skin.

ABCD, ABCD the Bark.

HHH sap Vessels in arched Parcels.

I the Parenchyma.

CDEF the Wood.

ddd the true Wood, in which the dark Spots are the Air Vessels.

KK the Insertions.

EF a Ring of other sap Vessels.

EFG the Pith.

Between GG, FF, is shewn the Position of the Bladders in perpendicular Rows.

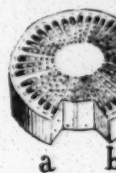
Between DD and BB is seen the same of the Bark; and

Between FF DD is seen an upright Section of the Wood and Air Vessels.

S E C T. II.

Of the Bark of Trees.

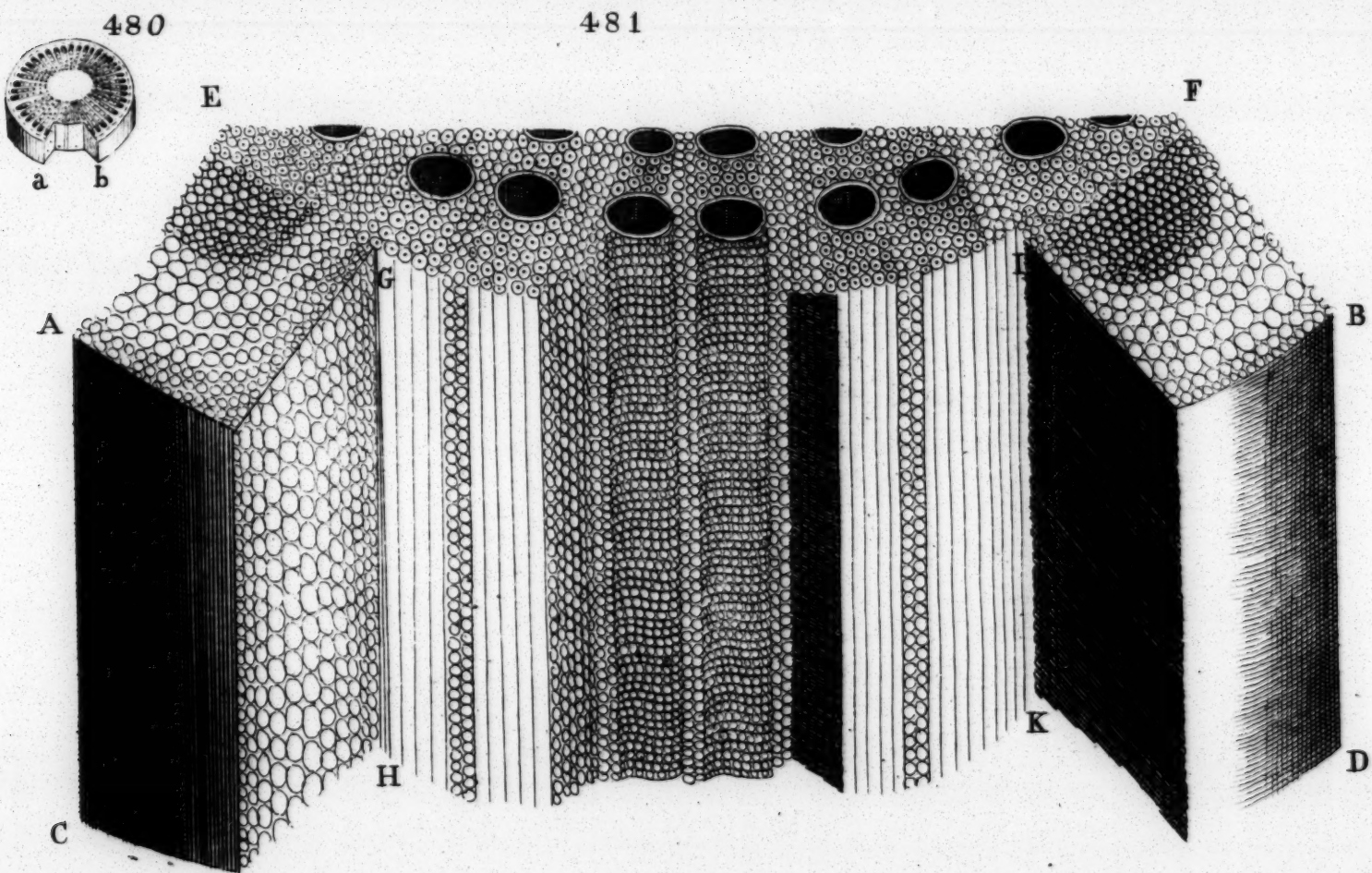
THE exterior Part of Trees is the *Bark*, and serves them for a Skin or Covering; in general it is of a spongy Texture, and by many little Fibres, which pass through the capillary Tubes whereof the Wood consists, communicates with the Pith; so that the proper Nutriment of the Tree being imbibed by the Roots, and carried up through the fine arterial Vessels of the Tree by the Warmth of the Soil, &c. to the Top of the Plant, is usually supposed to be there condensed by the cold Air; and returns by its own Gravity down the Vessels, which do the Office of Veins, lying between the Wood and inner *Bark*, leaving, as it passes by, such Parts of its Juice as the

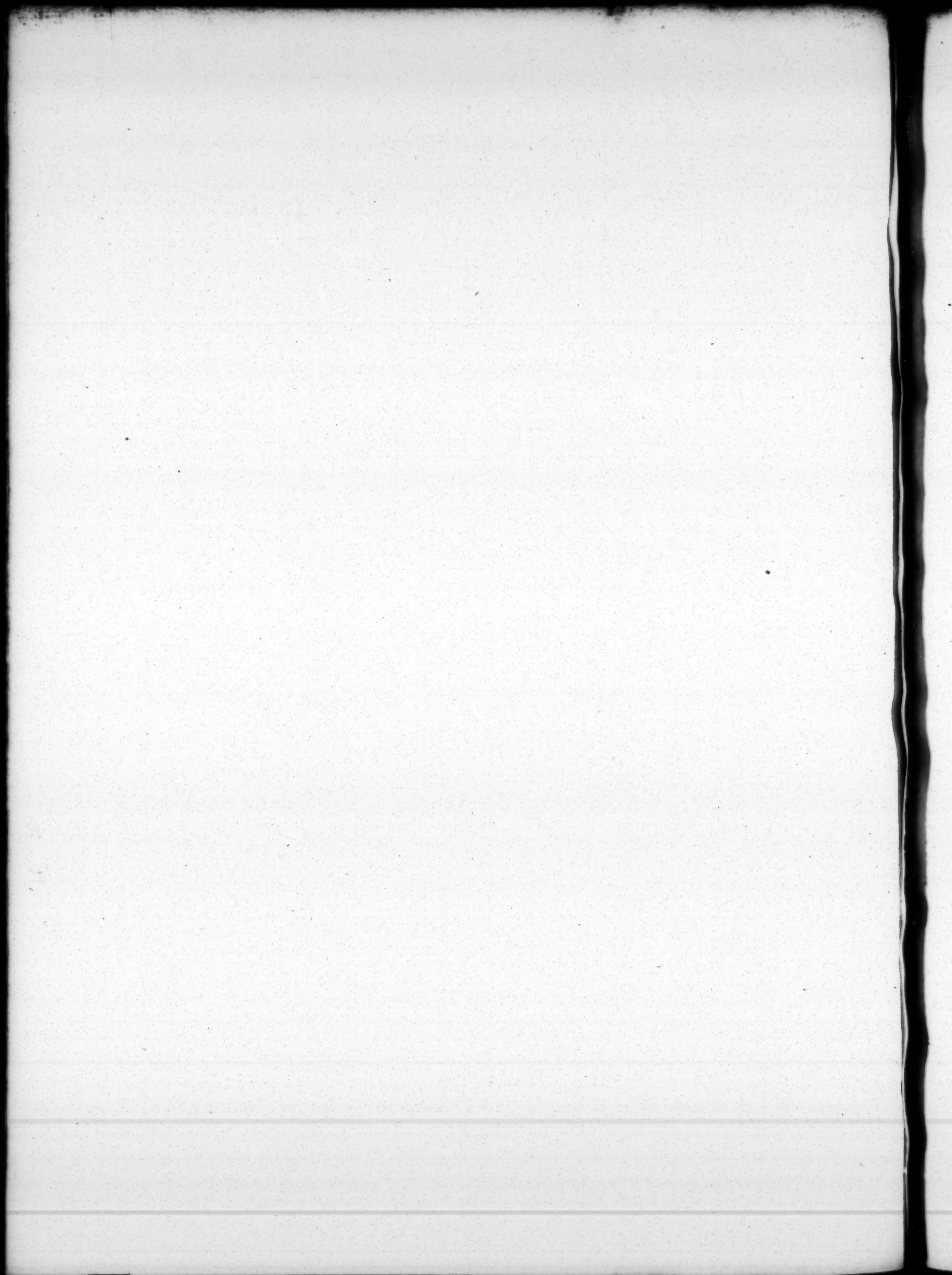


A

C

J. Wiggley.





the Texture of the Bark will receive and requires for its Support. That soft whitish Rind or Substance, between the inner Bark and the Wood, which, Mr. Bradley thinks, does the Office of Veins; some account a third Bark, differing only from the others in the Closeness of its Fibres; 'tis this contains the liquid Sap, Gums, &c. found in Plants in the Spring and Summer Months. It hardens by little and little, by means of the Sap it transmits, and is imperceptibly converted into the woody Part of the Tree. There are few Trees but what have it; yet it is still found in less Quantity as the Tree is more exposed to the Heat of the Sun. It is here the Corruption of Trees generally begin; whence those who fell and cut Trees ought always to take Care to leave as little of it on as possible.

The Bark consists of two Parts, the outmost Skin and the main Body; the Skin is generally composed of very small Vesicles or Bladders; but as the Plant grows, the Skin dries, and the Bladders shrink up and disappear. Amongst these skinny Bladders are intermixt a Sort of woody Fibres, as in *Malloy*, *Nettle*, *Borage*, *Thistle*, and most Herbs.

The Skin of the Trunk is sometimes visibly porous, as in the better Sort of *Walking Canes*; Fig. 476. ABCD.

The main Body of the Bark also consists of two Parts, the Parenchyma and Vessels; the Parenchyma is composed of an infinite Number of small Bladders, and the Vessels are very numerous standing in or near the inner Margin of the Bark, and are always sap Vessels*.

The Properties of the said Vessels are distinguished from one another in the same Plant, and in the several Species of Plants; which Properties are not accidental, but such as shew the constant and universal Design of Nature.

For in the Figures 482, 484, 486, 488, the Vessels of the Bark are only of two Kinds, which in the first two seem to be roriferous† and Lymphæducts (yet in all the four their Number and Position is very different.) In *Hazel*, Fig. 484, they are but few; in *Apples*, Fig. 482, they are more, and also in *Pear*, *Plumb*, *Elm*, &c. still more numerous. As to their Position in *Hazel*, the Lymphæducts or Vessels next the Wood, stand in semi-circular Parcels; and in *Holly* they stand in Rays, yet so numerous and close together as to make one intire Ring. In the *Apple Branch*, Fig. 482. the Lymphæducts OO are radiated, they are also radiated in the *Pear* and *Plumb*, &c. In *Hazel*, Fig. 484. the roriferous Vessels HI, as Dr. Grew calls them, make an intire Ring. In *Apple*, Fig. 482, they are neither radiated nor make an intire Ring, but stand in peripheral Parcels, much after the same Manner they stand in *Elm*. In *Ash* the Vessels make two Rings, the inmost or Lymphæducts consist in arched Parcels, and the outmost or roriferous of round ones; whereas in the foregoing the Lymphæducts are contiguous to the Wood, and the roriferous more or less distant

* Grew. Ana. Plant, p. 108.

† Ibid. 109.

from the Skin ; here, on the contrary, the first are distant from the Wood, and the latter contiguous to the Skin.

In the two next Branches, Fig. 486 and 488, the Vessels of the *Bark* are also different in Number, Position, Size and Kind. In *Pine* they are less, and in *Walnut* more numerous ; as to their Position, the inmost DC in *Pine*, Fig. 488, compose a radiated Ring, the utmost are straggling up and down without any certain Order. In *Walnut*, Fig. 486, the inmost DC make also a radiated Ring, and the utmost a double Ring HRI, not radiated but of round Parcels : As to their Kind, they differ most apparently from the Diversity of Saps those different Vessels contain ; which in the Bark of *Pine*, Fig. 488. are also of two Sorts, the inmost are Lymphæducts, as in the two former ; the outmost are not Milk, but Gum Vessels, or resiniferous, and stand straggling or singly about the Bark ; all the clear Turpentine that drops from the Tree issues from these Vessels, which are apparent even to the naked Eye ; whereas those of the Lymphæduct are not to be discerned without the Assistance of a *Microscope*.

The two next Pieces of Branches are common *Sumach*, Fig. 494. and common *Wormwood*, Fig. 490, which are remarkable for their having three kind of Vessels in the *Bark*, whereas the former have only two. First then in common *Sumach* is a thick radiated Ring DMC of Lymphæducts, standing on the inner Margin of the Bark contiguous to the Wood ; these Vessels exhibit their Lympha very apparently. The second Kind of Vessels XX compose a Ring, and are situate near the outward Margin of the *Bark*. Between these two Kinds stand the Milk Vessels KML, each of which being empaled or hem'd in by an Arch of roriferous Vessels.

The next is a Branch of common *Wormwood*, Fig. 490, in the *Bark* of which are also three kinds of Vessels ; first there is a thin radiated Ring, CDLK of Lymphæducts, contiguous to the Wood, yet this Ring is not entire, but made up of several Parcels ; which are intercepted by as many parenchymous ones, inserted from the *Bark* into the Pith. The second Sort of Vessels KL, which seem to be roriferous, are situate near the Middle of the Bark, and stand in arched Parcels ; these also compose a Ring.

Beyond these Arches, and towards the outer Margin of the *Bark*, stand a third Sort of Vessels HMI, their Content is a kind of a liquid, oleous and viscid Gum, which for its pleasant Flavour may be called an *aromatick Balsam* *, because it perfectly affordeth whatever is in the Smell or Taste of *Wormwood*, being the Essence of the whole Plant, so that they are in all Respects analogous to the Turpentine Vessels in *Pine*.

The Structure of the Milk and Gum Vessels when viewed with the *Microscope*, seem to be made by the Constipation of the Bladders in the Bark, that is to say, they are so many Channels, not bounded by any Sides proper to

* *Grew An. Plants, p. 111.*

themselves, as a Quill thrust into a Cork, or as the Air Vessels in the Wood, but by the Bladders of the Parenchyma * which are so crowded up together, as to leave certain tubular Spaces throughout the whole Length of the Bark.

One Difference between those Vessels just describ'd, and these hollow Tubes, &c. in the Pith, is this, that they are not originally formed with the Pith, but are formed partly by the stretching it undergoes from the Dilatation of the Wood, and partly from the drying and shrinking up of its Bladders, and of their component Fibres; whereas the Vessels in the Bark are many of them originally formed † therewith; and those which succeed them are not caused by any Rupture as those in the Pith are, but from a regular Disposition of the parenchymous Fibres, and Constipation of the Bladders thereof; all which will appear very plain upon viewing the three Figures 477, 478, and 479.

It has been before observed, that the lignous or towy Parts of all Plants are tubular, and that the Juices are conveyed the whole Length of the Plant through an infinite Company of small Tubes.

These very Tubes or Lymphæducts are likewise made up of other yet much smaller Tubes, set round together in a cylindrical Figure; by which also appears the admirable Smallness of these Fibres; for there are some Lymphæducts that may be reckoned 50 Times smaller § than an Horse-hair, and that those minute Fibres are also composed of other such Fibres, but much smaller, is not altogether improbable; allowing therefore but 20 of these to compose a Thread no bigger than one of these Lymphæducts; then one of these Fibres must be 1000 Times smaller than an Horse-hair.

They may be observed in a very white and clear Piece of Ash torn carefully lengthways, and sometimes also in a very white Piece of Fir.

In the *East Indies* they manufacture the *Bark* of a certain Tree into a kind of Stuff or Cloth; it is spun and dress'd much after the Manner of *Hemp*: The long Filaments which are separated from it, upon beating and steeping it in Water, compose a Thread, of a middle Kind between Silk and common Thread, neither so soft or bright as Silk, nor so hard or flat as Hemp. Some of these Stuffs are pure *Bark*, and are called *Pinasses*, *Biambonnes*, &c. In others they mix Silk with the Bark, and call them *Ginghams* and *Nillas*; the *Fontalungees* too, are part Silk, part Bark, and are only distinguished by being stripped.

* *Grew Ana. Plants*, p. 113.

† *Ibid.*

§ *Ibid.* p. 112.

S E C T. IV. Of the Wood.

THE next general Part of a Branch is the Wood which lies between the Bark and Pith, it is composed of parenchymous and lignous Parts ; the parenchymous Part of the Wood in all Trees, though much diversified, is disposed into many Rays or Insertions running between as many woody Portions, from the Bark to the Pith. These Insertions are various according to the several Sorts of Trees or Plants, in Pine, Fig. 488, and Wormwood, Fig. 490. they are not so numerous as in Sumach, Fig. 494. in the Apple, Fig. 482, or in the Hazel, Fig. 484.

These Insertions do not run only through the Wood, but also shoot out beyond it into some Part of the Bark, as in *Elm*, *Sumach*, *Wormwood*, &c.

The Texture likewise of these Insertions is also various in Wormwood and most Herbs, they are manifestly composed of small Bladders, yet larger in these than in Trees.

The *Wood* is likewise composed of two Sorts of Bodies, that which is strictly woody, and the Air Vessels. The true *Wood* is nothing else but a Mass of antiquated Lymphæducts, viz. those which are originally placed on the inner Margin of the Bark ; for in that Place there annually grows a new Ring of Lymphæducts, which by degrees losing its first Softness, is at the latter End of the Year turned into a dry and hard Ring of perfect *Wood*. Whence it is evident that the Bark of a Tree is divided into two Parts, and distributed two contrary Ways ; the outer Part falleth off towards the Skin, and at length becomes the Skin itself. The outward Skin of a Tree is not originally made a Skin, but was once some of the middle Part of the Bark itself, which is annually cast off and dried into a Skin ; the inmost Portion of the Bark is yearly distributed and added to the Wood, the parenchymous Part thereof makes a new Addition to the Insertions within the *Wood*, and the Lymphæducts a new Addition to the woody Pieces between which the Insertions stand ; so that a Ring of Lymphæducts in the Bark this Year will be a Ring of Wood the next, and another Ring of Lymphæducts and of Wood successively from Year to Year ; so in Fig. 482, of part of an *Apple Branch* cut transversely, three Years Growth, are represented in that of Sumach, Fig. 484. one Year only is exhibited, and in that of *Walnut*, Fig. 486. are shewn four Years Growth of Wood between the Letters D C E F.

Here also may be observed, that certain Parcels of Wood make either several small white Rings, as in *Oak*, or several white and crooked Parcels transverse to the Insertions, as at D C, K L, &c. in *Walnut*, Fig. 486.

In the Branches of *Fir*, *Pine*, &c. are a few Turpentine Vessels dispersed
up

up and down the *Wood*. The Air Vessels with the Insertions, and true Wood altogether, make up that which is commonly called the Wood of a Tree.

The Variety of the Air Vessels are many, with respect both as to their Number, Size, and Position, and are not to be found alike in any two Sorts of Plants whatsoever: As to their Number it is very great, in *Apple*, *Pear*, *Hazel*, &c. but in different Degrees, they are represented by all the black Spots in the Wood, in all the Figures before referred to.

Their Sizes are as different as the Trees to which they belong, being at least twenty Times bigger in *Elm* or *Oak*, than in *Holly* or *Pear*, &c.

Their Situation is also different: In *Apple*, Fig. 482. and in *Walnut*, Fig. &c. they are spread abroad in every annual Ring; in others they keep more in the Compass of some Line or Lines, either diametrical or peripheral. In *Holly*, &c. they are radiated or run in even diametrical Lines between the Pith and Bark.

Whether the Air Vessels are irregular or radiated, Nature hath so disposed them, as that many of them stand always near the Insertions.

In *Ash* the Air Vessels stand in Circles on the inner Margin of every annual Ring. These Circles are in some very thick, as in *Ash* and *Barberry*, in some thin, as *Elm*, &c.

Their Form is such that they are never ramified, but continued from one End of a Plant small or great, quite through to the other End thereof.

As to their Texture they oftentimes appear to be unwreathed in Form of a very small Plate, which also is not only of different Breadths in different Plants, and usually broader in the Root than in the Trunk; but also the said Vessels are oftentimes unwreathed, not in the Form of a Plate but of a round Thread. The Causes of which Diversity are principally three, the Westage of the Fibres of which the Air Vessels consist: The Difference between the said Fibres, or between the Warp and Woof, and the different Kinds of Woof.

By the Westage of the Fibres it is, that the Vessels oftentimes untwist in the Form of a Plate; as if a fine narrow Ribband be wound spirally, and Edge to Edge, about a Stick, and then the Stick being drawn out, will leave the Ribband in the Form of a Tube * and of one of these Air Vessels, for that which upon the unwreathing of the Vessel seems to be a Plate, is as it were a natural Ribband, consisting of a certain Number of Threads or round Fibres, standing parallel as the Threads do in a Ribband; and as in a Ribband so here, the Fibres which make the Warp and run spirally, do not grow together, but are held in that Position by other transverse Fibres which embrace them, and are in the Place of the Woof.

And as the said Fibres are transversely continued thereby making a Warp

* *Grew. An. Plan.* p. 117.

and Woof, so are they (as in divers Woollen Manufactures) of different Bulk; those of the former being stronger and bigger than those of the latter; by which Means, as Cloth and Silk will usually tear sooner one Way than another; so here while the Warp or those Fibres which run spirally are unwreathed, without breaking the smaller ones which hold them together, easily tear all the Way.

In the following Figures are shewn the Position of the Vessels in several Sorts of Timber cut Length-wise and Cross-wise as follows:

Fig. 507. represents a small Piece of the Wood of an *Oak-Tree*, cut transversely, and of its natural Size; and Fig. 508. A B C D, shews the same Piece as it appeared before the *Microscope* when greatly magnified, whereof the Parts F F seemed to be brown dark Streaks, the Wood included between the Spaces H I and K L, is the Breadth of that Circle which the Tree had increased in one Year. E E are the Cavities of very large Air Vessels, which run the Lengthway of the Tree. These large Vessels are composed of several smaller Membranes, as may be seen at Fig. 512. which represents part of one of the aforesaid Air Vessels seen length-wise, and as it appeared before the Magnifier.

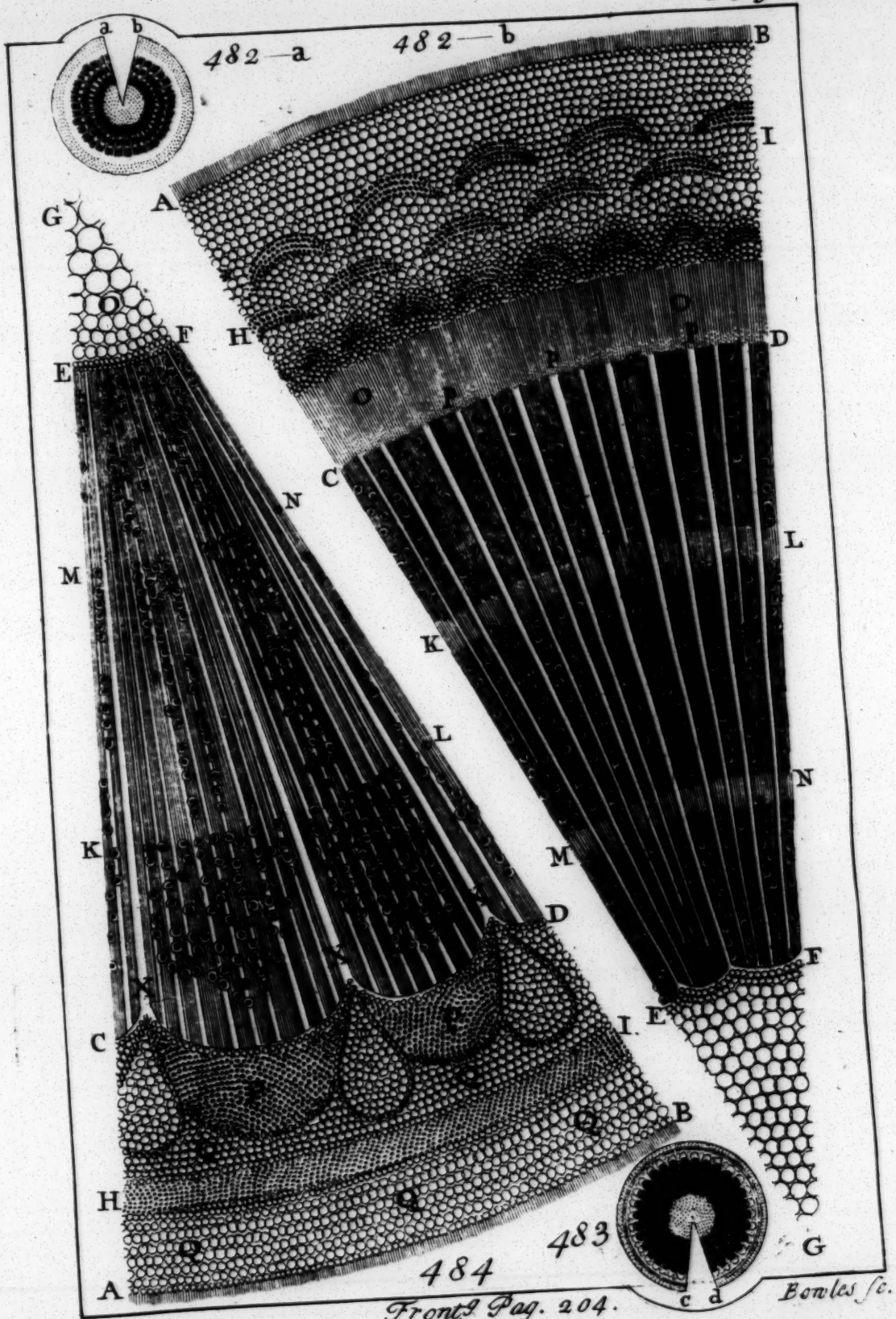
The second Sort of perpendicular Vessels which tend upwards, are seen at e e, Fig. 508. and are also composed of exceeding fine Skins, * in which are seen some Spots that in the Microscope appear like Globules, as at O N, Fig. 511. which shews one of these second Sort of Vessels cut lengthwise.

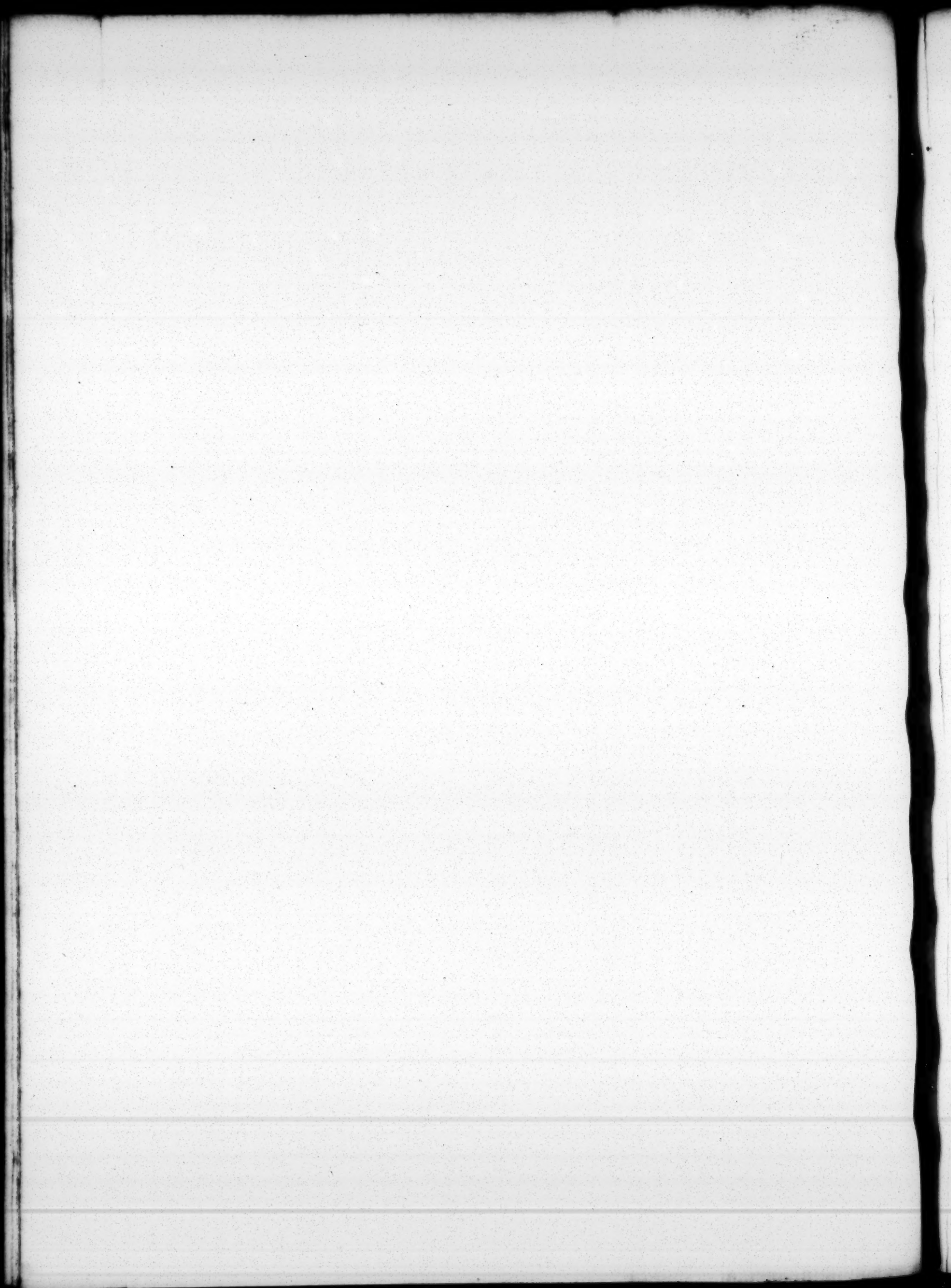
The third Sort of these Vessels which run upwards, are extremely small and in great Abundance, as appears throughout the whole Space H I K L, Fig. 508. These also are composed of extremely fine Skins; they are seen length-ways between P Q, Fig. 511.

G G G, Fig. 508. are another Sort of Vessels, which run horizontally from the Bark to the Pith: These seemed to extend themselves in Furrows, and were crooked or bowed round the Knots. When the *Wood* is cut length-wise, these horizontal Vessels are cut across, as at G G G, Fig. 511. The second Sort of horizontal Vessels are greatly numerous, which when the Oak is cut length-wise, are also cut across, and appear to the naked Eye as Fig. 513.

Fig. 496. shew a Piece of *Elm* cut transversely as it appeared to the naked Eye; and Fig. 497, a *microscopick* Picture of the same. A B, C D is the Breadth of the Ring the Tree had increased in one Year. The smaller perpendicular Vessels are situate between and joined to the larger, having smaller ones between them, as in Oak; the Tubes here also are composed of skinny Membranes. A C and B D, Fig. 497, are horizontal Vessels seen lengthwise. Fig. 498, is an upright Section of the Wood of *Elm* magnified, in which G G shews the exceeding small Vessels length-ways,

* *Leeuwen. Anat. & Contemp. Vol. 1. p. 3.*





H H is the Cavity of one of the great Vessels, being full of Turpentine Threads, or little Tubes, with black Spots curiously wove together; as at Fig. 499.

Fig. 500. is a small and thin Piece of *Beach*, cut transversely, and Fig. 501. represents the same as it appear'd in the *Microscope*. Its Length between A B and D C is the Breadth of a Circle, of one Year's Growth. The perpendicular Vessels in this Wood are of two, and the horizontal Ones of three Sizes; of which those expressed by E E, Fig. 501. are exceeding small; in the upright Section, Fig. 502. these horizontal Vessels are cut transversely, and shewn by H H, the second Sort of horizontal Vessels are seen lengthwise, from D to A, Fig. 501. and a transverse Section of the same Vessels are seen in the upright Section of the Timber, Fig. 502. at I, I, I, and at K K are seen the great perpendicular Vessels.

Fig. 509. represents a transverse Section of a small Bit of *Black Ebony*, greatly magnified, of which G, G, G, are the large upright Vessels. K K, in Fig. 510. shews one of these large Vessels cut lengthwise, and at Fig. 511. is seen another of a larger Sort, in which are many Streaks and Spots. The second Sort of perpendicular Vessels are seen between A B, A B, and the third Sort between C D, C D; a fourth Sort are squarish, and included between the second and third in the upright Section, Fig. 510. L L shews the smallest Vessels, and I, I, the transverse Sections of the horizontal Ones.

Fig. 503. A B C D is a small Piece of *Box*, cut transversely, and of the same Size to the naked Eye as the Piece of *Ebony*. This Wood also consists of large and small perpendicular Vessels intermix'd; the large ones are compos'd of Skins, and are full of extremely minute Particles, as may be seen in the upright Section thereof at E E, Fig. 504. the Cavities of the lesser Vessels are shewn lengthways at F E. A B and C D, Fig. 503. are horizontal Vessels, running lengthways, and at G G, Fig. 504. is seen a transverse Section of the same.

A B C D E F, Fig. 505. represents a transverse Section of a small Piece of *Straw*. A B E F is the shining Bark, composed of an incredible Number of exceeding small Vesicles. G G G G are Vessels, or rather Bladders, having four, five, or six Sides, and compose the greatest Part of the Inside of the *Straw*. H H H are some of the before-mentioned Vessels, intermixed with, or surrounded by a great Number of exceeding small Vessels. At Fig. 506. the same Vessels are seen lengthways in a perpendicular Section of the *Straw*.

S E C T. V.

Of the Pith.

THE third general Part of a Branch is the *Pith*, being in Substance nearly allied to the Parenchyma in the *Bark*, and the *Insertions* in the Wood.

Its Size is various, not being the same in any two Branches here represented. In Wormwood, Fig. 490. and Sumach, Fig. 494. it is very large. In Pine, Fig. 488. and Walnut, Fig. 486. not so large. In Apple, Fig. 482. and Hazel, Fig. 484. it is smaller.

It is also remarkable, that the *Bark* and *Wood* in most Plants increase yearly; and the *Pith*, on the contrary, grows smaller.

The *Pith*, for the most Part, is furnished with a certain Number of Sap Vessels, which form a Ring round the Margin thereof. They are numerous and conspicuous in *Walnut*, Fig. 486. and in *Fig*, *Pine*, &c. and are of divers Kinds, being Lymphæducts in *Walnuts*, Lacteals in *Fig*, and Resiniferous in *Pine*.

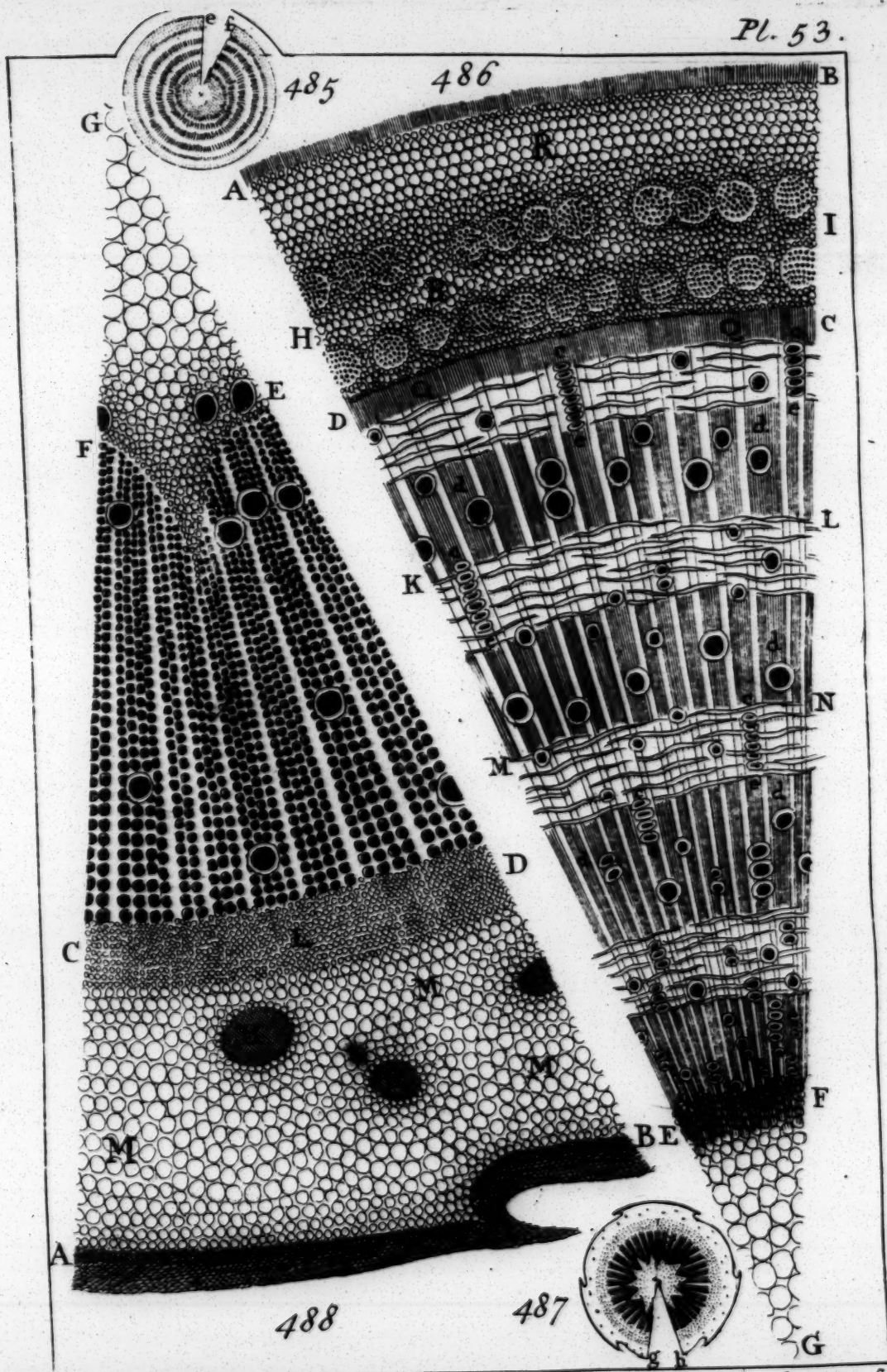
The Parenchyma of the *Pith* is composed of Bladders the very same with those in the *Bark*, and oftentimes in the *Insertions* within the Wood, only these of the *Pith* are largest, those in the *Bark* less, and these in the *Insertions* least of all.

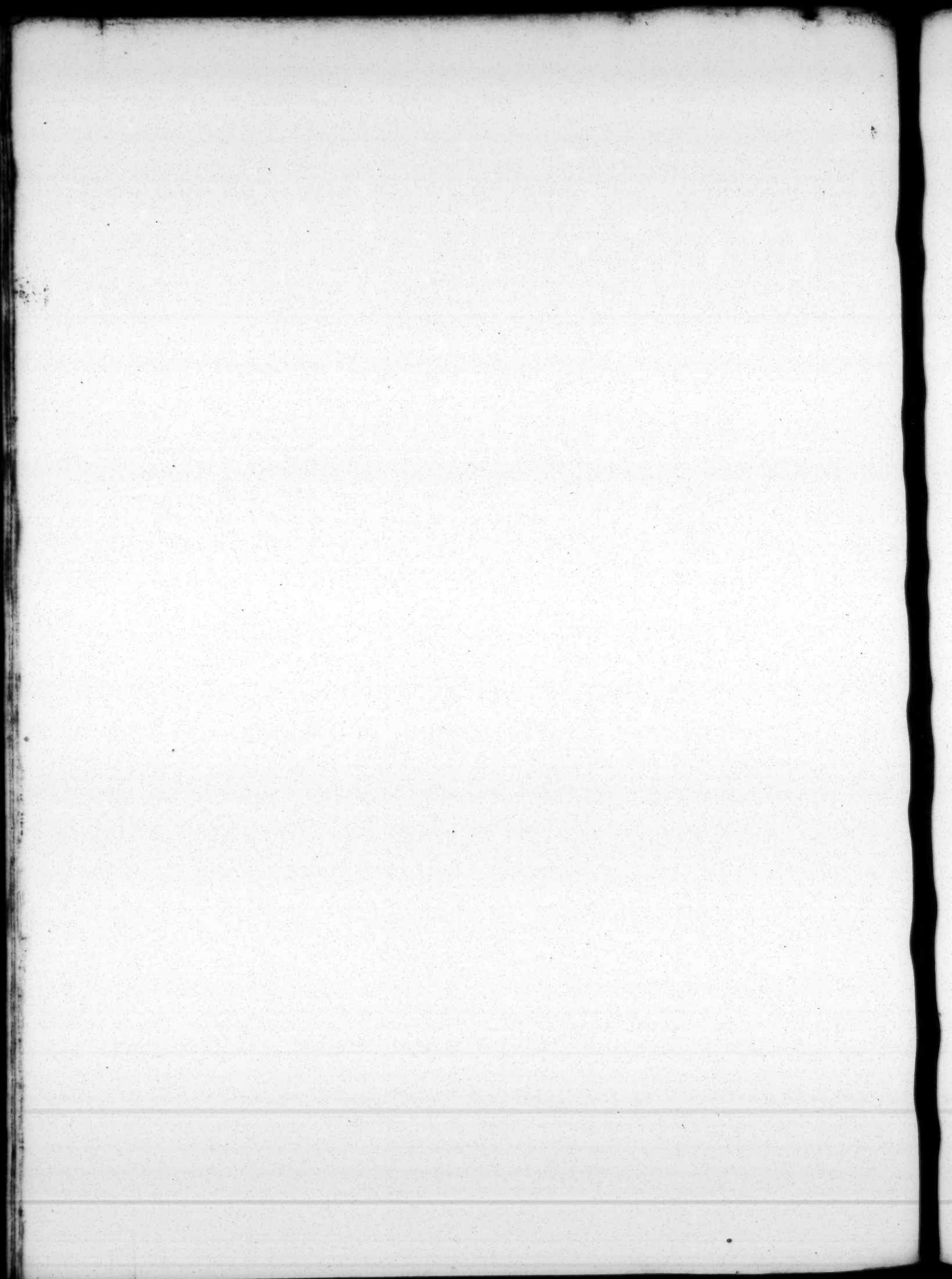
The Bladders of the *Pith*, tho' always comparatively great, are of very different Sizes. Those of *Thistle*, *Borage*, &c. appear in the *Microscope* like the Cells of an Honey-Comb; the Bladders in *common Thistle* and *Borage*, are so large as to contain within their horizontal Area, about twenty Bladders of the *Pith* of *Oak*. Wherefore one Bladder in *Thistle* is at least an hundred times bigger than another in *Oak*.

The Shape of the *Pith* Bladders admit of some Variety, they are for the most Part round, yet oftentimes angular, as in *Reed Grass*, a Water Plant; where they are also cubical; in *Borage*, *Thistle*, and many others they are pentangular, sexangular, and septangular.

As to the Texture of these *pithy* Bladders, they are oftentimes composed of smaller ones, as in *Borage*, *Bulrush*, and many other Plants.

Whence it appears, that as the Vessels of Plants, viz. the Air Vessels and Lymphæducts are made up of Fibres, so the *Pith*, or the Bladders of which the *Pith* consists, are likewise composed of Fibres, which is also true of the Parenchyma of the *Bark*, and of the *Insertions* in the Wood, and even of the Fruit, and all other parenchymous Parts of a Plant, and that the very Pulp of an *Apple*, *Pear*, *Cucumber*, *Plumb*, or any other Fruit, is nothing else but a Ball, of most extremely small transparent Threads or Fibres, joined together





together in a different, but curious Manner, even all those Parts of a Plant, which are neither formed into visible Tubes, nor Bladders, are made up of Fibres; and though it be difficult to discover them in those Parts which are the most compact and close, yet in the *Pith* which consists of more open Work, they are visible; and that in the *Pith* of a *Bulrush*, *common Thistle*, &c. not only the Threads of which the *Bladders*, but also the single Fibres of which the Threads are compos'd, may be distinctly seen, when placed before the *Microscope*.

The Fibrosity of the Parenchyma is also visible in some Woods, being interwove with the lignous Parts, and with every Fibre of every Vessel, as in very white *Ash* or *Fir* may be discover'd.

Whence it follows, that all the Parts of a Plant consist of Fibres, of which those of the Lymphæducts run lengthwise, those of the Pith, Insertions, and Parenchyma of the Bark horizontally, those of the Air Vessels begin their Circuit horizontally, and continue it in Height or lengthwise.

From what has been said, there appears to be a great Similitude between the Mechanism of *Plants* and *Animals*, the Parts of the former seem to bear a constant Analogy to those of the latter; and the *Vegetable* and *Animal* Œconomy seem to be both formed on the same Model; for from the foregoing Observations, and the Assistance of the *Microscope*,

First, the *Root* is found to be a spongy Body, whose Pores are disposed to admit certain humid Particles, prepared in the Ground.

Second, the *Wood* which consists of capillary Tubes running parallel from the Root throughout the Stalk, (the Apertures of those Tubes are too minute to come under the Cognizance of the naked Eye) these Mr. *Bradley* calls *arterial Vessels*; it being through these that the Sap rises from the Root.

Third, besides these there are other larger Vessels, disposed on the Outside of the arterial Vessels between the Wood and the inner Bark, and leading down to the Covering of the Root, which he also calls *venal Vessels*, and supposes them to contain the liquid Sap found in *Plants* in the Spring.

Fourth, the *Bark* being of a spongy Texture, which by many little Strings communicates with the *Pith*.

Fifth, the *Pith*, or Pecten, which consists of little transparent Globules, chained together somewhat like the Bubbles that compose the Froth of Liquor.

Malpighi was the first who observed, that Vegetables consists of two Sorts of Vessels. 1. Those abovementioned, which receive and convey the alimental Juices. 2. *Tracheæ*, or *Air Vessels*, which are long hollow Pipes, wherein Air is continually received and expelled, *i. e.* within which *Tracheæ* he shews all the former Series's of Vessels are contained.

Hence

Hence it follows, that the Heat of a Year, nay of a Day, of a single Hour, or Minute, must have an Effect on the Air, included in these *Tracheæ*, i. e. it must rarify it, and consequently dilate the *Trachea*; whence also must arise a perpetual Spring or Force of Action to promote the Circulation in *Plants*.

For by the Expansion of the *Tracheæ*, the Vessels containing the Juices are pressed; and by that Means the contained Juice is continually propelled, and so accelerated; by which same Propulsion the Juice is continually comminuted and rendered more and more subtle, and so enabled to enter Vessels still finer and finer; the thickest Part of it being at the same Time secreted and deposited into the lateral Cells, or Loculi of the *Bark*, to defend the Plant from Cold and other external Injuries.

The Juice being thus conveyed from the *Root*, to the remote Branches, and even to the Flower; and having in every Part of its Progress deposited something both for Aliment and Defence; what is redundant passes out into the *Bark*, the Vessels whereof are inosculated with those wherein the Sap is mounted; and through these it descends to the Root, and thence to the Earth again, and thus is Circulation effected.

Thus is every Vegetable acted on by Heat during the Day-time, and the Sap Vessels thus are squeezed and press'd, and the Sap protruded and raised, and at length evacuated, and the Vessels exhausted in the Night again; the same *Trachea* being contracted by the Coldness of the Air, the other Vessels are eased and relaxed, and so disposed to receive fresh Food for the next Day's Digestion and Excretion.

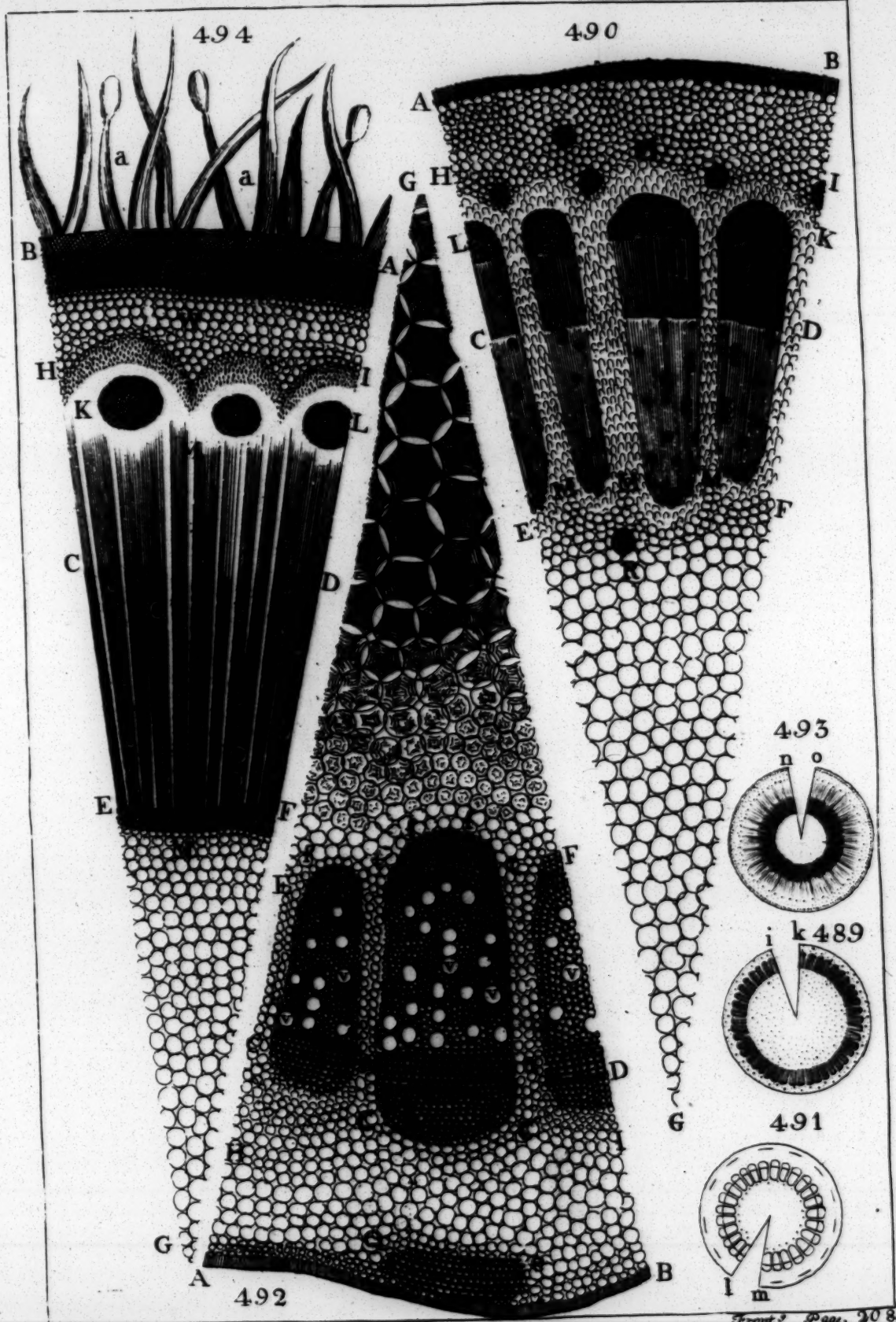
The Juice being carried on to the *Germ*s or *Bud*, is more concreted; and here having unfolded the *Leaves*, which being exposed to the alternate Action of Heat and Cold, moist Nights, and hot scorching Days, are alternately expanded and contracted; and the more on account of their reticular Texture.

By such Means the Juice is farther altered and digested, as it is further yet in the *Petala*, or Leaves of the Flowers, which transmit the Juice, now brought to a further Subtlety to the *Stamina*; these communicate it to the *Farina*, or Dust in the *Apices*, where having undergone a farther Maturation, it is shed into the *Pistil*, and here having acquired its last Perfection, gives Rise to a new Fruit or Plant.

Fig. 514, and the four following Figures, represent the Structure of the woody Fibres and Lymphæducts both in the Bark and Wood.

Fig. 514, shews a single Vessel in the *Bark* of *Flax*; and Fig. 515. represents the same Vessel as seen in the *Microscope*, and greatly magnified; whence it appears to be composed of a great Number of other lignous Fibres, with which also the Parenchymous are intermixt.

Fig. 516, exhibits a Parcel of the same Vessels in the Wood of *Fir*, greatly magnified; and at a, is seen the same Piece of its natural Size.



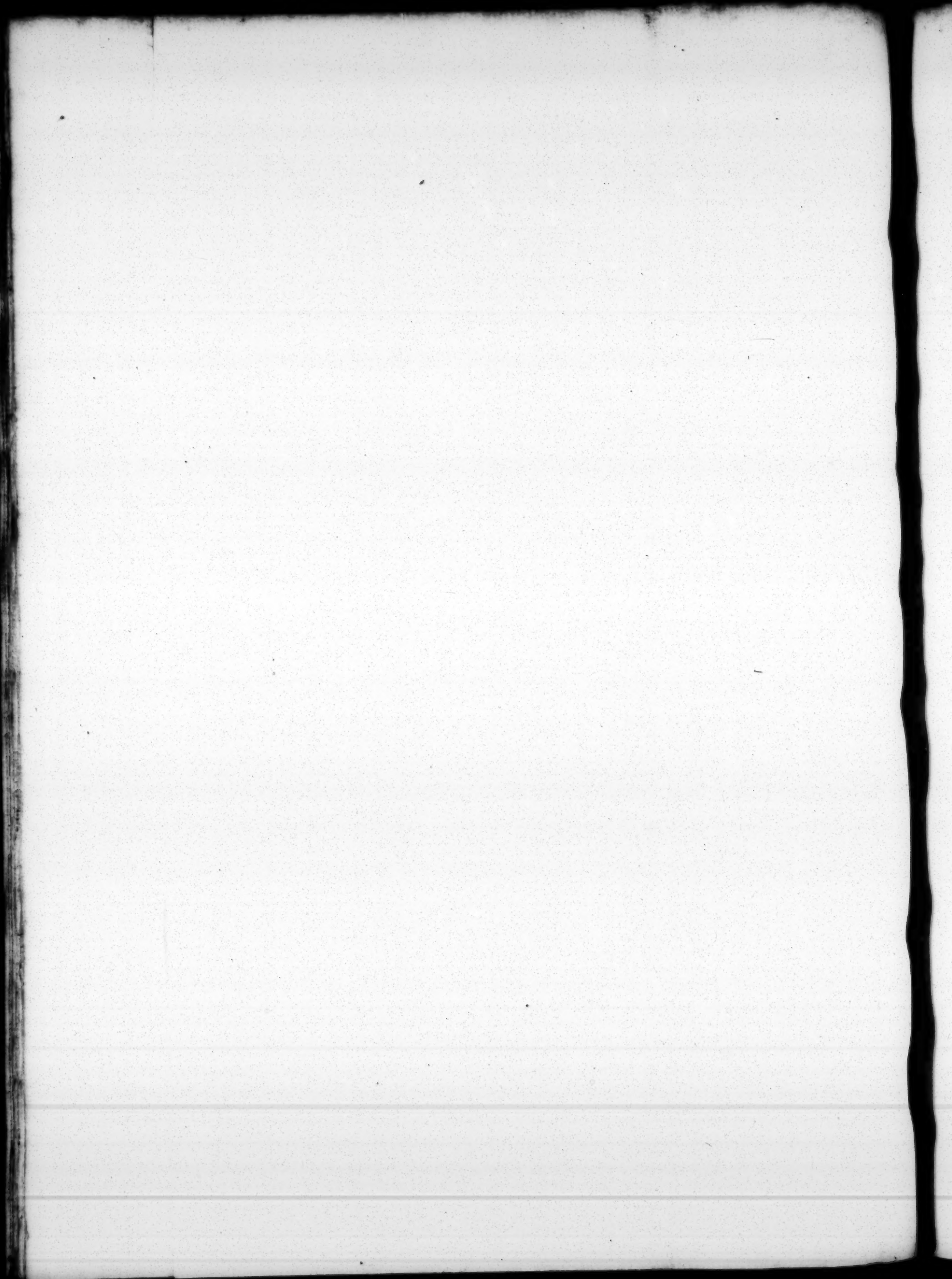


Fig. 517, AB, shews a Lymphæduct, and Fig. 518, C, represents a lactiferous Vessel, both of which are surrounded with parenchymous Bladders, and are greatly magnified.

Fig. 519, represents part of the Stalk of Sumach, somewhat larger (and more magnified) than that of Fig. 494, with several Breaks in it, to shew the Contexture both of the perpendicular and horizontal Fibres; in which, as before,

AB aa shews the hairy Skin.

ABCD the Bark in which the Fibres bb, cc, and dd, that hang down therefrom are Lymphæducts, one of which ddd, is composed of a great many other smaller Fibres.

HWI the Parenchyma.

DMC the common Lymphæducts.

KML the Milk Vessels composed of Bladders.

HI another Sort of Lymphæducts arched over the Milk Vessels.

DCEF the Wood, from which the Fibres ef, that hang down, are some of them the old Lymphæducts turned into Wood; ghgh are two Air Vessels in which the wreathing thereof is plainly seen, and from h to i is also seen Part of the same Vessels unwreathed.

OP is part of one of the Insertions composed of Bladders, and those Bladders of Threads.

EFG is part of the Pith composed of thready or fibrous Bladders.

C H A P. XXXVIII.

Of Leaves.

S E C T. I.

THE *Leaves* of Trees or Plants are full of innumerable Ramifications, that convey the perspirable Juices to the Pores for their Discharge. The Fibres of the Leaf do not stand in even Lines from the Stalk, but always in an angular or circular Posture, and their vascular Fibres or Threads are 3, 5 or 7; the Reason of their being in this Position, is for the more erect Growth and greater Strength of the Leaf, as also for the Security of its Sap. Another Observable in the Fibres of the *Leaf*, is their orderly Position, so as to take in an eighth Part of a Circle, as in *Mallows*, in some a *Tenth*, but in most a *Twelfth*, as in *Holy-Oak*, or a *Sixth*, as in *Syringa*.

The Art of folding up the *Leaves* before their Eruption out of their Gems, &c. is incomparable both for its Elegancy and Security, viz. in taking up (so as their Forms will bear) the least Room; and in being so conveniently couched, as to be capable of receiving Protection from the other Parts, or of giving it to one another, *e. gr.* first there is the *Bow-lap*, where the *Leaves* are all laid somewhat convexly, one over another, but not plaited, but where the *Leaves* are not so thick set as to stand in the *Bow-*

E e

lap;

lap; there we have the *Plicature*, or the *flat Lap*, as in *Rose-tree*, &c. To these Dr. Grew adds their various Foldings, which he calls by the Names of the *Duplicature*, *Multiplicature*, the *fore Rowl*, *back Rowl*, and *tre Rowl* or *treble Rowl*.

To these curious Foldings may be added another noble Guard by the Interposition of Films, &c. of which Dr. Grew saith there are about six Ways, viz. *Leaves*, *Surfoyls*, *Interfoyls*, *Staks*, *Heads*, and *Mantlings*.

The various Methods which Nature takes to preserve the Leaves from the Injuries both of the Ground and Weather are, viz. the young Buds of *Ammi*, at their first Eruption from the Ground, are couched, as *Fern* is rowled inward; each Bud, against the Brace of the Stalk of the foregoing Leaves, and most exactly inclosed in the Membranes thence produced. Nature hath generally provided them with another Protection, where the Stalks of the Leaves are so long that they cannot lap over each other, the Bottoms of the Stalks are expanded into broad Membranes, as in *Crows-foot*, *Doves-foot*, *Clover*, *Cransbill*, *Strawberry*, *Harrow*, &c. and sometimes instead of two Skins lapped over each other, one entire Skin is produced from the Stalk, in which, as within a Secundine, the Bud is safely lodged, which it gradually breaks open in its Growth.

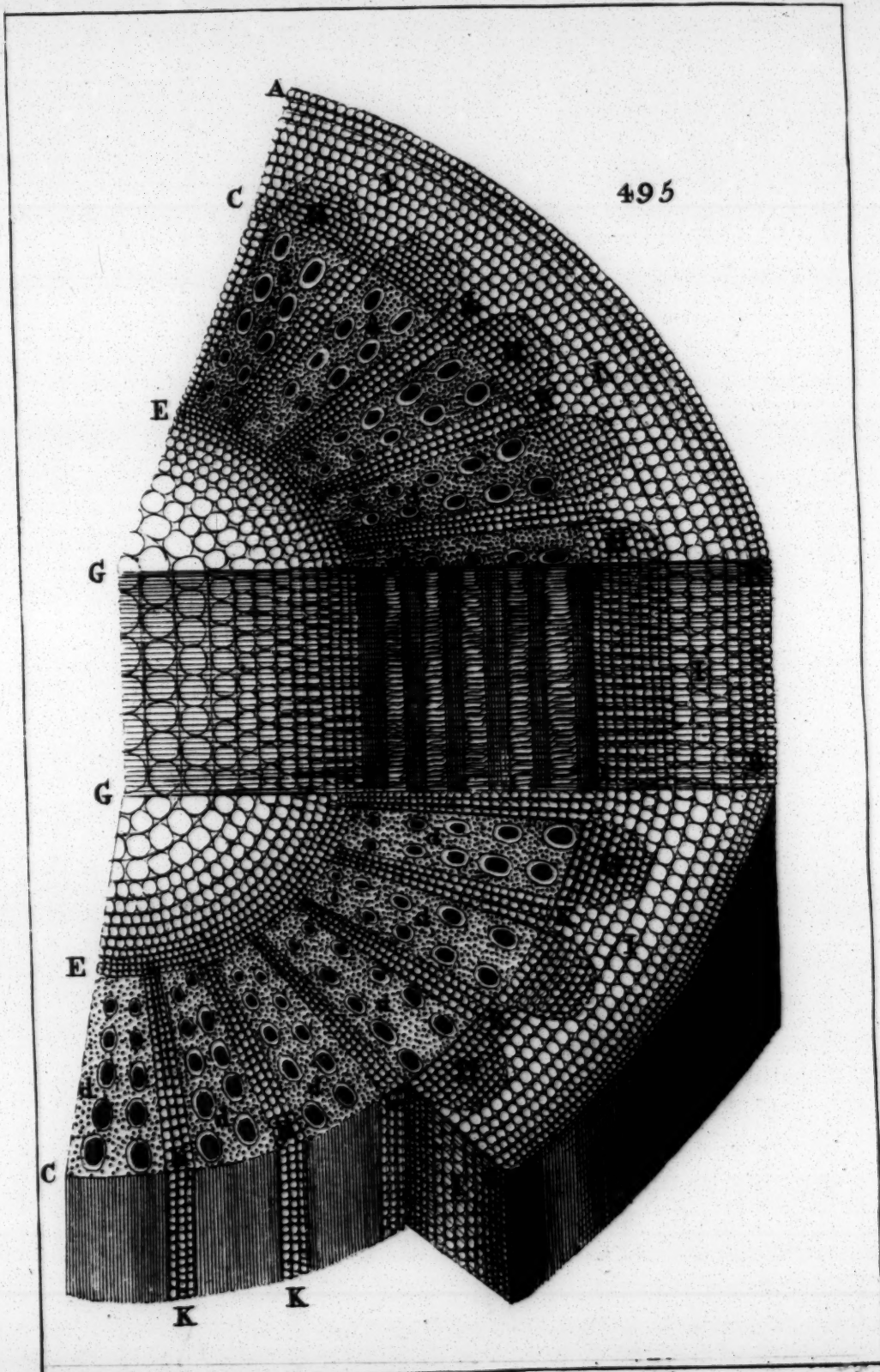
It is also observable in *Dock*, *Sorrel*, *Bistort*, and all other Plants of this Sort, with this Difference, that every Veil or Secundine is not here produced from the Stalk of the *Leaf*; whereas in the former every Bud hath one to itself in these Plants, every lesser *Leaf*, together with its own proper Veil, is always inclosed with the next greater *Leaf* in another common to them both, and both these with the next in another, and so on to the greatest. The *Orchis*, and other Plants of this Sort, have a double Sheath over all. The Buds of some Herbs as *Plantain*, having no Hairs growing over them, are covered with hairy Thrums, and the *Nettle* hath Bastard-leaves or Interfoyls between *Leaf* and *Leaf*, for the Preservation of its Stings.

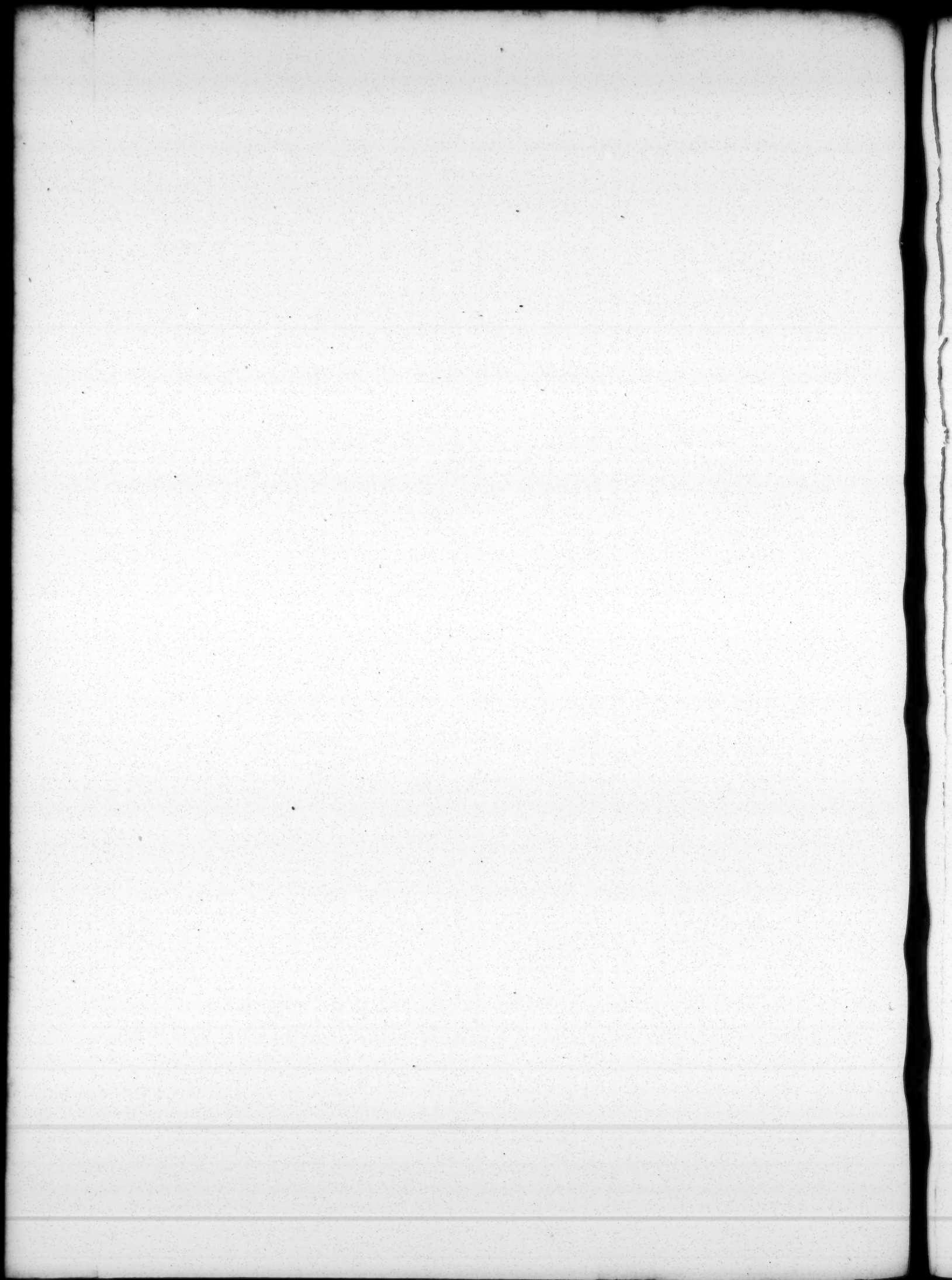
Another Sort of Protection is seen, in white *Archangel*, and other Plants of a like Shape. In which the greater *Leaves* do also inclose the lesser, by a double fore Curl at the Bottom of every two great *Leaves*, which embraces the little under Bud, and so keeps it clean and warm.

The *Leaves* of *Onions* are all Pipes one within another, having a small Aperture about the Middle common to all of them, even the most minute ones in the Center.

As the Buds of *common Sumach* are exceeding tender, Nature appears in a peculiar Manner solicitous for their Preservation, being lodged within the Body of the Stalk, as entirely as a Kernel is within an Apple; from whence it is that the Basis of every Stalk is extremely swelled.

There are also *globular Excrescencies*, *Spots*, *Hairs*, *Thorns*, and *Prickles*. Globulets are seen upon *Orach*, but more plainly upon *Bonus Henricus*,
in





in these growing almost upon the whole Plant, and being very large, are by most People taken Notice of ; but the *Microscope* hath discovered to us that they are the natural and constant Offspring of very many other Plants, they are of two Kinds transparent, as upon the Leaves of *Hysop*, *Mint*, *Baume*, &c. white on *Germander*, *Sage*, &c. Sometimes they appear like a fine Powder upon the Leaf, these were first white and transparent as in *Bears Ear*. If this be licked of, it will afford the Taste of the essential Content of the Plant. They frequently grow on both Sides the *Leaf*, yet sometimes, as in *Ground Ivy*, chiefly on the Back side thereof, and in many Plants where the Elder-leaves have none, on the young Buds they are very numerous, as in *Corin tree*, *Sorrel*, and others.

Spots are observable in *St. Johns-wort*, *Rue*, *Ground-Ivy*, *Pimpernel* or *Anagallis*, &c. when held up against the Light.

Thorns are lignous and cortical, the first are such as those of *Hawthorn*, somewhat like these are the Spinets or thorny Prickles, upon the Edges and Tops of divers *Leaves*, as *Baberry*, *Holly*, *Thistle*, *Furz*, &c.

Cortical Thorns are such as those of the *Raspberry-Bush*, being not, unless in an invisible Proportion propagated from the lignous Body. They are of Use not only for the Protection of the Bud, but also for the Support of the Plant.

The Use of Hairs on Leaves are to preserve young Buds, not only from the cold Air, but also from too much wet, which if it were contiguous would often rot and dry them. But being made to stand off in Drops, at the Ends of the Hair, does not hurt but refresh them. Thus we see by the Assistance of the *Microscope*, that Nature oftentimes makes the meanest Things subservient to the best Ends.

S E C T. II.

Of the Parts and Texture of the Leaf.

THE first Part which here presents itself is the Skin, a small Bit of which being stripped off the *Leaf*, and laid upon the Object carrying Glass R, of Fig. 2. or held between the Nippers, and then placed before the Microscope, will appear to consist of parenchymous and lignous Fibres, all very curiously and admirably interwoven, as in *Flag*, *Tulip*, &c.

From hence it is easy to conceive, that the Skins of all Plants (as well as those of Animals) are perspirable between the several Fibres of which they consist, formed into several Orifices, either for the better Avolation of superfluous Sap, or the Admission of Air, these Orifices are not in all Leaves alike, but varied in Bigness, Number, Shape and Position, and are the Cause of the Gloss on the Upper-side of the Leaves, the Backside having none of them.

Next the Skin lies the pulpy Part of the *Leaf*, called the *Parenchyma*, being composed of an incomparable Number of little cylindrical Fibres, which are in most Leaves wound up into minute Bladders, but generally more visible in the Stalk than in the Body of the Leaf. In some Leaves, as in *Borage*, Fig. 520. the greater Bladders are made up of lesser ones, and in some others these parenchymous Fibres are all drawn up close together.

The pithy Part in the Stalk, and almost up to the Top of the chief Fibre, in many Leaves is tubular, even whilst they are yet young and sappy, as in *Sweet Cervil*, *Hemlock*, *Endive*, *Cichory*, *Lampsana*, *Dandelion*, *Burdock*, *Daize*, *Scorzonera* and others, and sometimes the said pithy Part is opened into several pithy Pipes; the Fibres also of the Leaf, which is visible to the naked Eye, are composed of Sap and Air Vessels. Their Position is various and regular, not only in the Body of the Leaf, but likewise in the Stalk, as in the Stalk of a Mallow-leaf, Fig. 521. they stand in six oblong Parcels of equal Size, and in a Circle near the Circumference. In *Dandelion*, *wild Clary*, and in *Borage*, Fig. 522. they stand in five Parcels.

In the Body of the Leaf, besides the Positions of the fibrous Strings, there is one in particular which runs round the Edge of the Leaf in all Plants; but can hardly be well discover'd without stripping off the Skin of the Leaf. The Continuation of the Vessels seem to be ramified, and seems also to be inosculated.

These *Tracheæ* or Air Vessels are visible, and appear very pretty in the Leaf of *Scabious*, or the *Vine*, by pulling asunder some of its principal Ribs or great Fibres; between which may be seen the spiral Air Vessels (like Threads of a Cob-web) a little uncoiled, as represented by Fig. 523. which shews a Piece of a *Vine-leaf*, wherein these Vessels were drawn out and a little magnified, and at a, the spiral Circumvolutions are represented as they appear'd in the *Microscope* when greatly magnified, and as they stand in-tire within the Wood; and at b, is seen one a little stretched.

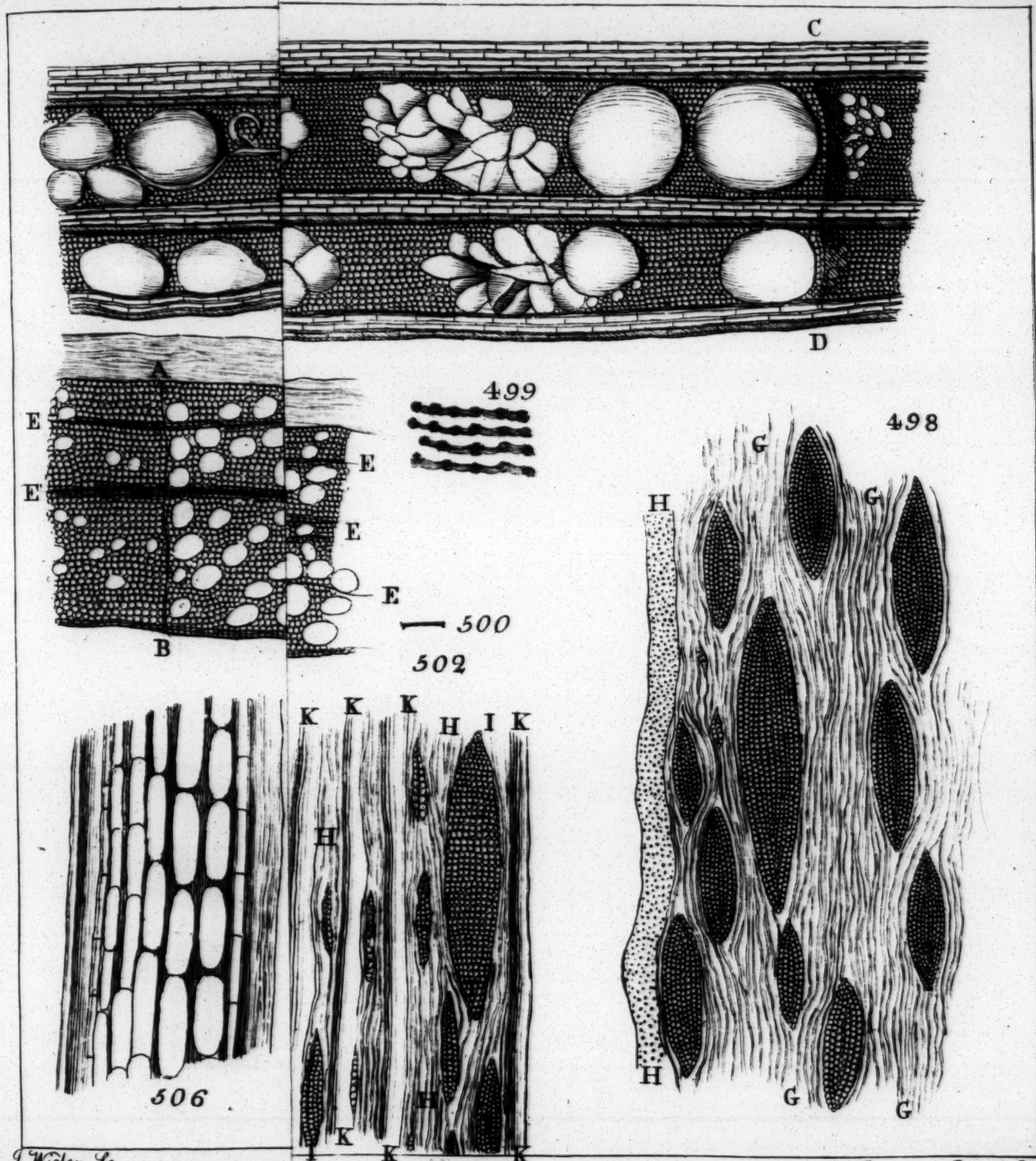
Mr. *Leeuwenhoek* tore a Leaf of *Box* to Pieces, called *Palma Cereris*, that he might the better examine it, and computed one Side thereof to contain 172090 Pores, and as the other Side must consequently have the same Number, the whole Pores in a *Box-leaf* will be 344180.

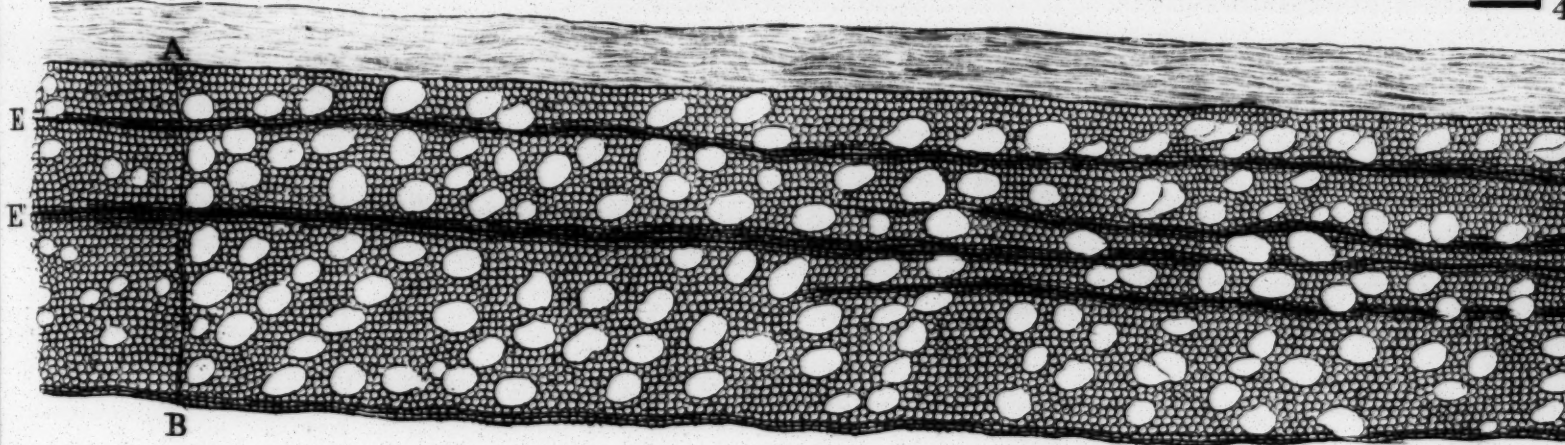
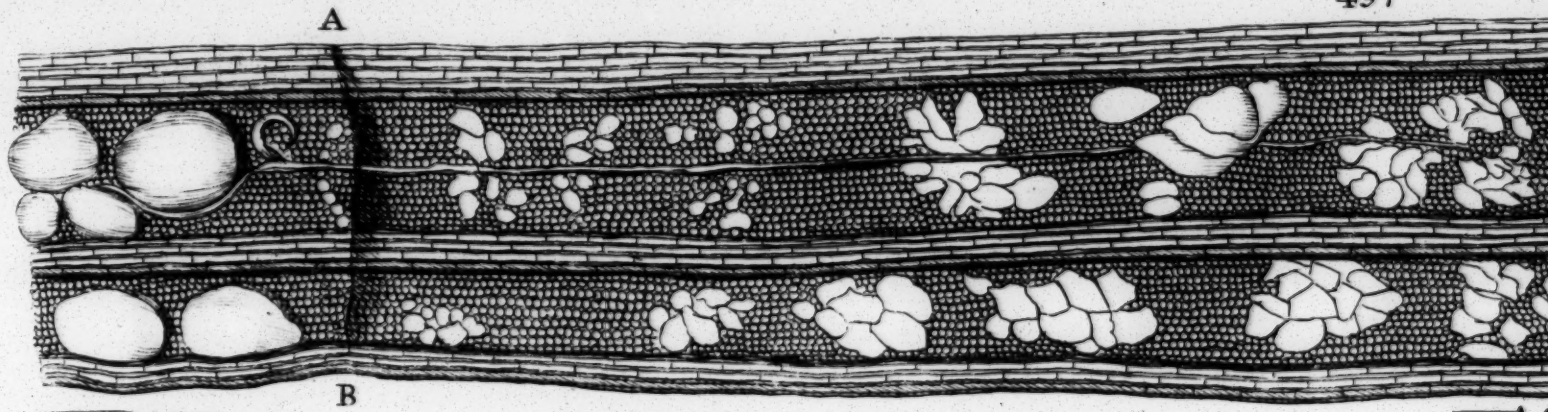
S E C T. III.

Of Rosemary-Leaves.

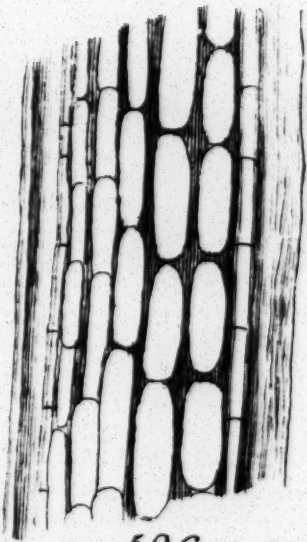
FIG. 524. represents a small Part of the Under-side of a *Rosemary-leaf*, * whereof AB shews Part of the Upper-side which was doubled over, and consisted of a smooth shining Substance, but its Under-side appeared

* *Ho. Mi. p. 142.*

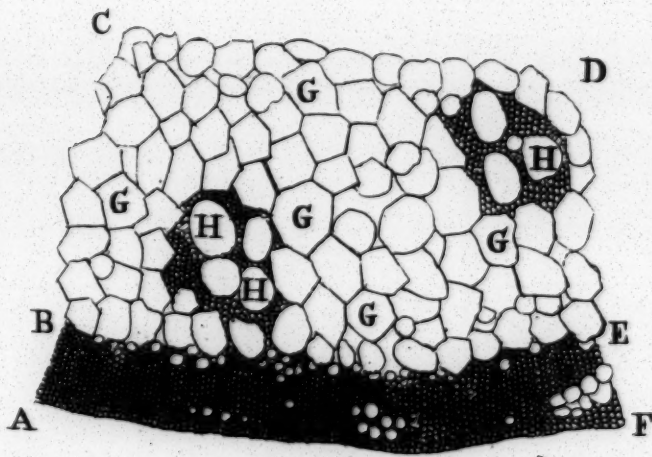




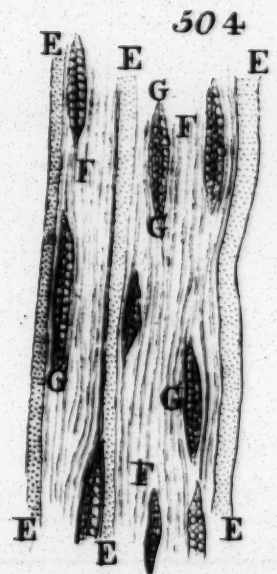
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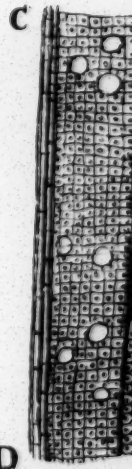
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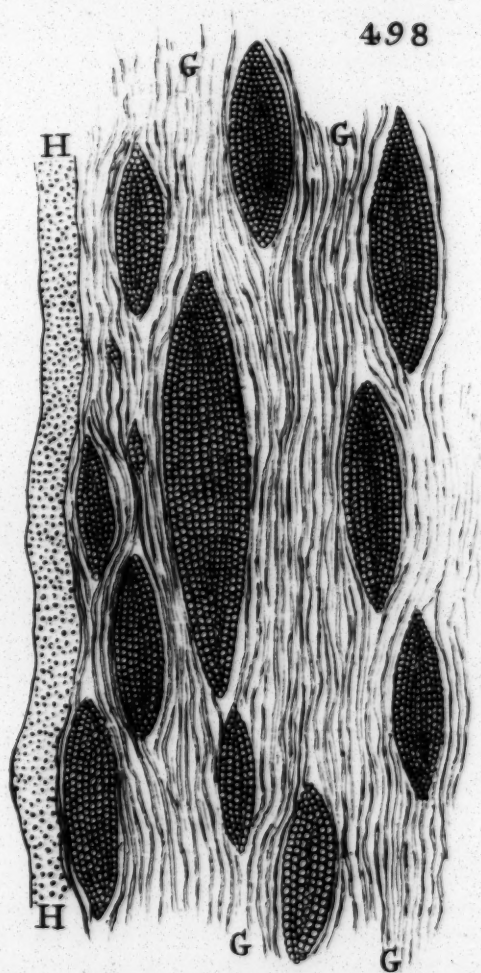
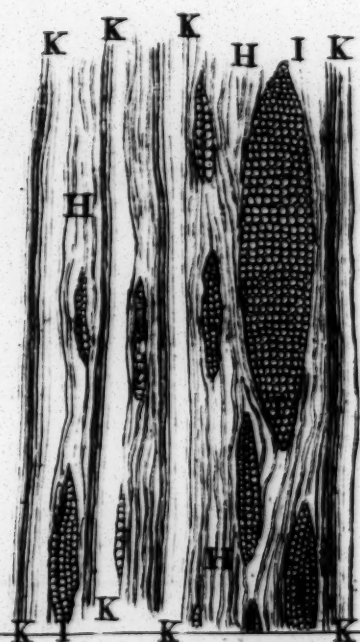
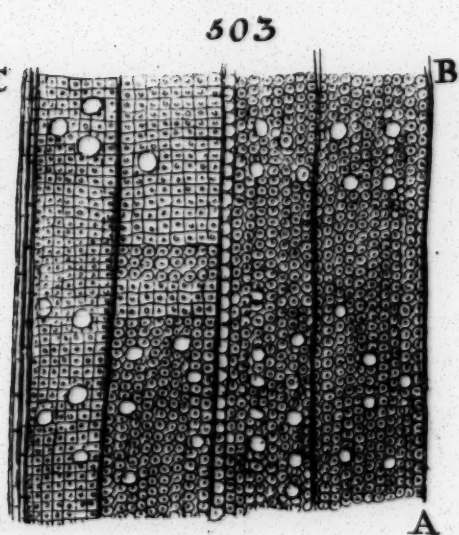
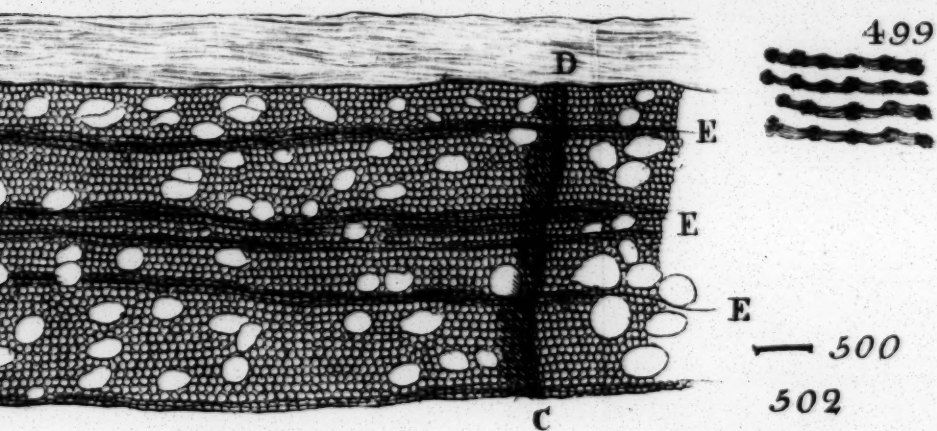
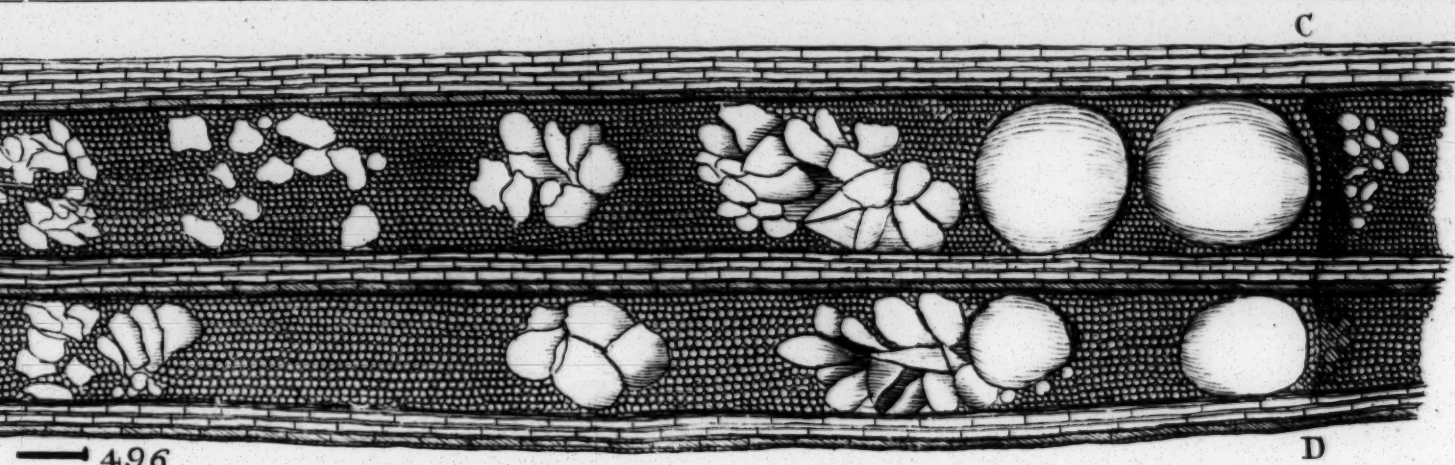


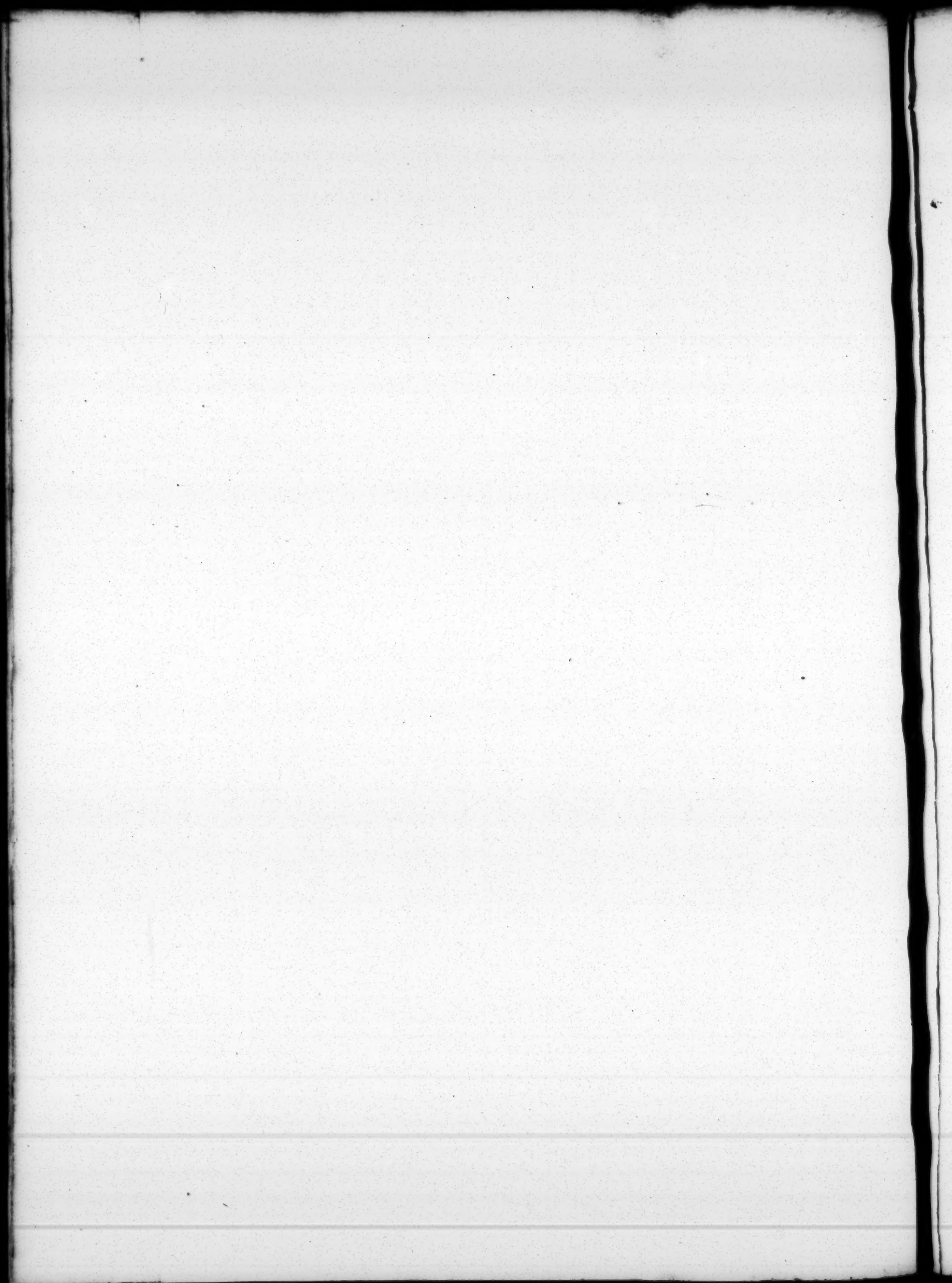
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in the *Microscope* like a Thicket of Bushes, amongst which were a great Number of round Balls, exactly globular, and afford a very agreeable Prospect.

The Back-side of a Rose-tree Leaf, but especially of a Sweet Briar-leaf, looks diapered with Silver.

The Back of the Leaf of *English Mercury* * looks as if rough cast with Silver, and all the Ribs set round with white transparent Balls.

A Leaf of Rue looks full of Holes like an Honey-Comb.

A Sage-leaf is tasseled with white Silver Thrums, and one or two Crystal Beads, or Pendants, fastned to every Knot.

S E C T. IV.

Of Stinging-Nettles.

A Nettle is a Plant known almost to every body, there being very few but what have felt as well as seen it; but how the Pain is so suddenly created, and by what Means continued, we must have recourse to the *Microscope* for our Information, and that will if almost any Part of the Plant be looked on, shew us the whole Surface thereof to be very thick set with sharp Points, that penetrate the Skin when touched, and occasion Pain, Heat, and Swelling; they are represented in a small Part of the Leaf as they appear in the *Microscope*, by Fig. 525. at A B, consisting of a rigid hollow Body tapering from B, till it terminate in the most acute Point imaginable, being exceedingly clear and transparent. At the Bottom of this Cavity lies a minute Bag B, containing a limpid Liquor, † which, upon the least Touch of the Prickle, is squirted through the little Orifice, and if it enters the Skin, produces the before-mentioned Mischiefs by the Pungency of its Salts. C D shews one of the chief Fibres of the Leaf, from whence the Stings proceed.

The other Parts of the Leaf or Surface of the Nettle have very little considerable, but what is common to most Plants, as the Ruggedness, Indenting, and Hairiness, and other Roughnesses of the Surface, on the Outside of the Plant.

S E C T. V.

Of Cowage, or Cowitch.

T H E R E is a certain Down of a Plant, brought from the *East-Indies*, which grows on a Kind of hairy Kidney Bean §. The Pods about three Inches long, resemble a *French Bean*, and are cover'd with this Down

* *Pow. Mi. Ob.* p. 50.

† *Hook's Mi.* p. 143.

§ *Ibid.* p. 146.

or Hair, which is very stiff for its Bigness, and causes Pain, and Inflammations, if rubbed on any Part; and when viewed by the Microscope, this Down appears to be a Multitude of pointed Thorns exquisitely sharp.

S E C T. VI.

Of the Texture of the Leaves of Sea-Weeds.

IT is a Plant which grows upon the Rocks under Water, increasing and spreading itself into a great Tuft, which is not only handsomely branched into several Leaves; but its whole Surface is cover'd over with a curious Kind of carved Work, * consisting of a Multitude of very small Holes, ranged in the neatest and most delicate Order; a small Piece thereof is represented as it appear'd in the Microscope, at Fig. 526.

C H A P. XXXIX.

Of Flowers.

A*Flower* is that Part of a Plant which contains the Organs of Generation, or the Parts necessary for the Propagation of the Kind.

It is a natural Production, which precedes the Fruit, and yields the Grain or Seed.

Their Structure is somewhat various, though the Generality, according to Dr. Grew, have these three Parts entire, the *Empalement*, the *Foliation*, and the *Attire*.

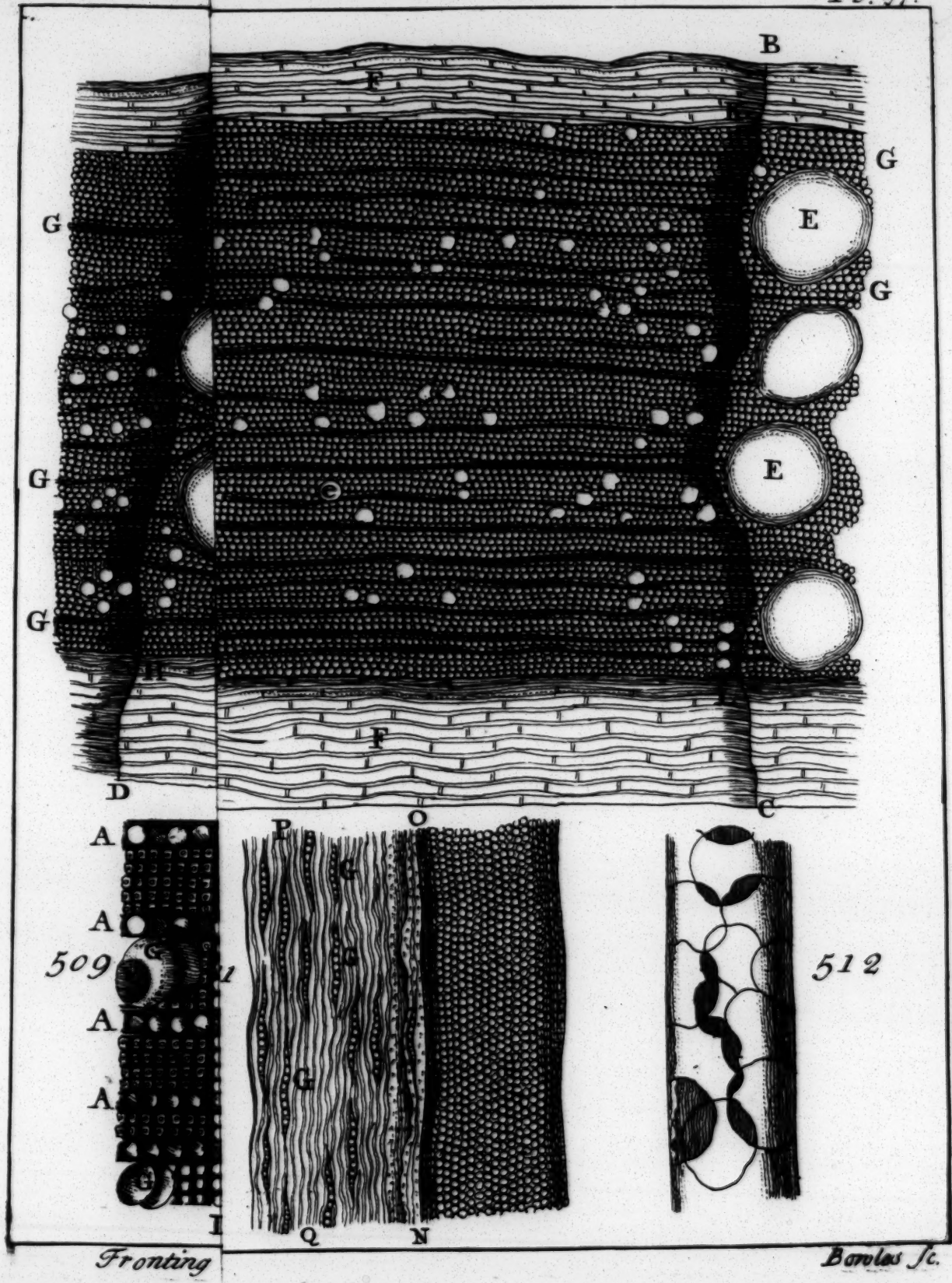
Mr. Ray reckons, that every perfect *Flower* has the *Petala*, *Stamina*, *A-pices*, and *Stylas*, or *Pistil*; such as want any of these he deems imperfect Flowers.

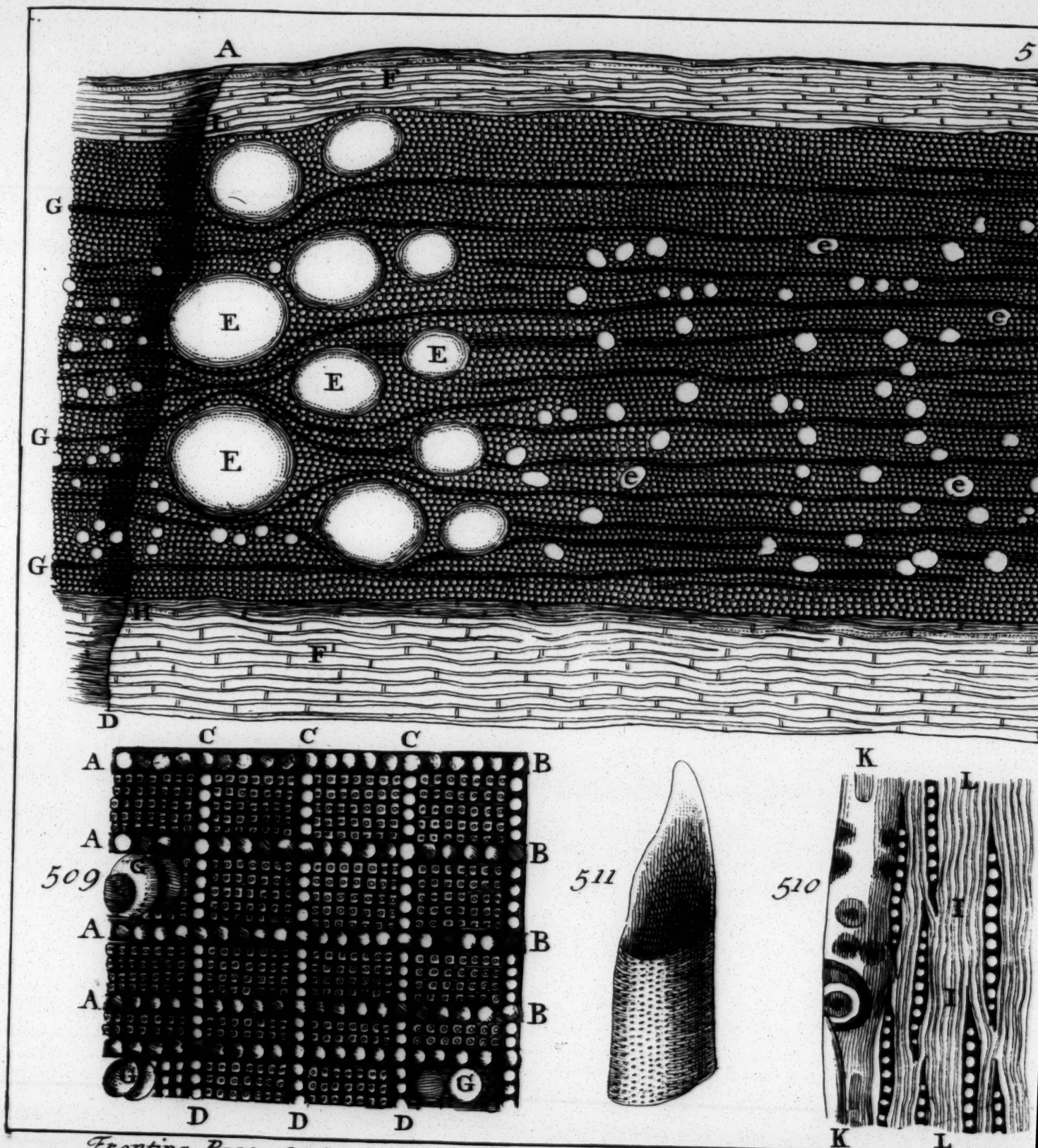
In most Plants there is a *Perianthium*, *Calyx*, or Flower Cup, of a stronger Consistence than the Flower itself, and designed to strengthen and preserve it.

Flowers, whose *Petala* are strong (as *Tulips*) have no *Calyx*; Carnations, whose *Petala* are long and slender, have an *Empalement* of one Piece; and others as *Knap-Weeds*, have it consisting in several Pieces, and in divers Rounds, and all with a counterchangeable Respect to each other, for the greater Strength and Security of themselves and the *Petala*, &c. they include.

The next is the *Foliation*, as Dr. Grew, the *Petala*, or *Folia*, as Mr. Ray, and others; in these, not only the admirable Beauty, and luxuriant Colours are observable, but also their curious Foldings, in the Calx before their Ex-

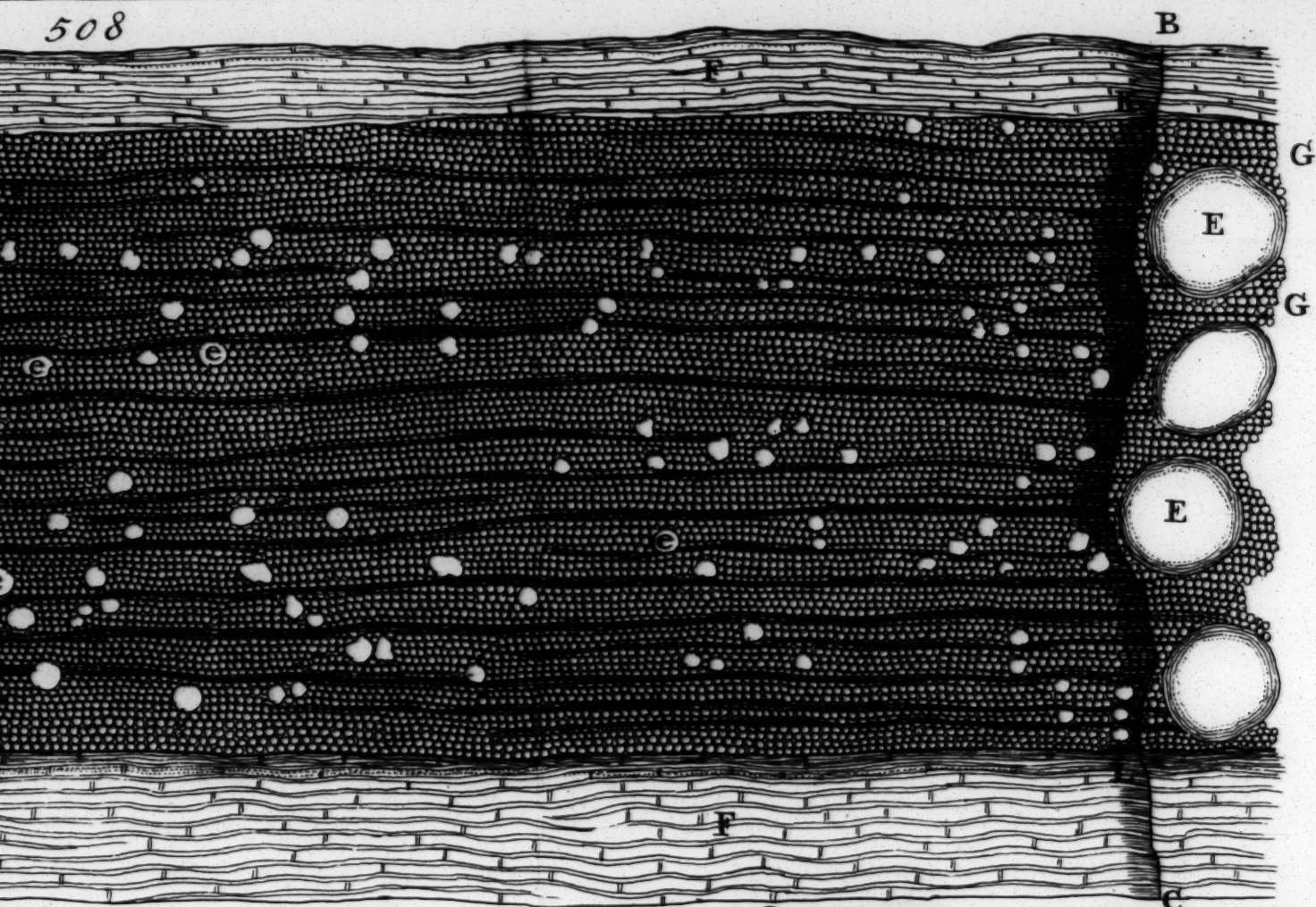
* Hook's Mi. p. 140.





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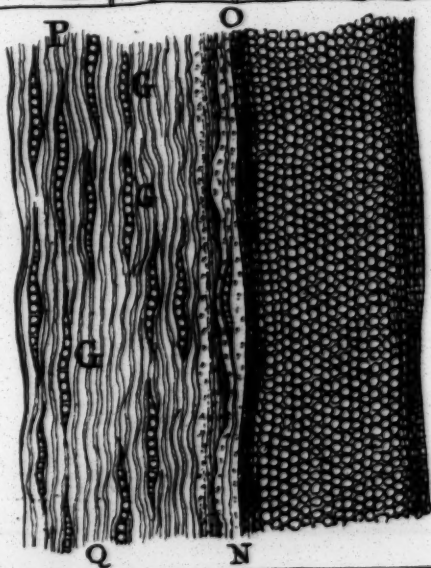
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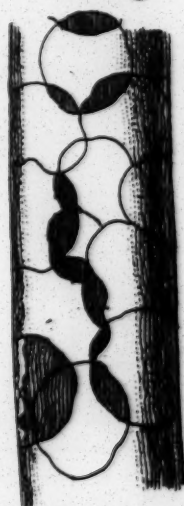
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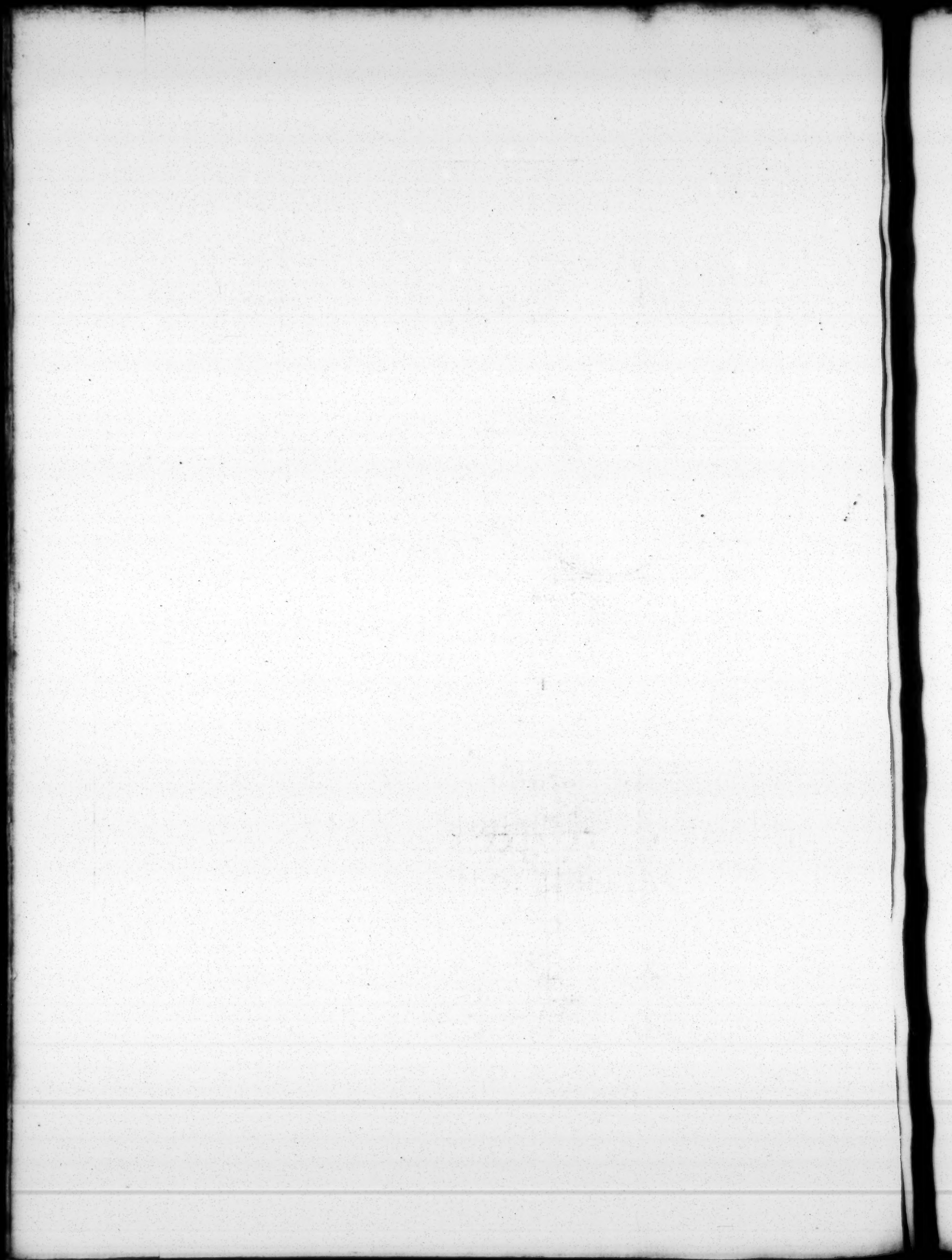


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panfion, of which Dr. *Grew* hath thefe Varieties, viz. the Clofe Couch, as in *Rofes*, and feveral other double Flowers; the Concave-Couch, as in *Blattaria*; *Flora albo*, the fingle Plait, as in Peafe-Bloffoms; the double Plait, as in Blew-bottles, &c. the Couch and Plait together, as in *Marigolds*, *Daizes*, &c. The Rowl, as in *Lady Bower*; the Spire, as in *Mallows*; and laftly, the Plait and Spire together, as in *Convolvulus Doronici Folio*.

As to the Stamina with their Apices and Stylus (called the Attire by Dr. *Grew*) they are admirable, whether we confider their Colours, or their Make, but efpecially their Ufe, if it be as Dr. *Grew*, Mr. *Ray*, and others imagine, namely, as a *Male Sperm*, to impregnate and fructify the Seed; which Opinion is corroborated by the ingenious Obfervations of Mr. *Samuel Moreland*, viz.

All *Flowers*, in general, or at leaft the greateft Part of them, are furnifhed with Chives, Tops, and Piftils.

The Farina, or fine mealy Powder, which is at its proper Seafon, fhed out of thofe Thecæ or Apices; Seminiformes, which grow at the Top of the Stamina, does in fome Meafure perform the Office of a *Semen Mafculinum*, by dropping upon the Outfide of the Uterus or *Vasculum Seminale*, and impregnate the included Seed, &c. But Dr. *Moreland* was of Opinion, that the Seeds which come up in their proper Involucra, are at firft, like the unimpregnated Ova of Animals; * that this Farina is a Congeries of feminal Plants *, one of which muft be conveyed into every Ovum, before it can become prolific. That the Stylus, as Mr. *Ray*, or the upper Part of the Piftulum, as Mr. *Tournefort* calls it, is a Tube defigned to convey thefe feminal Plants into their Neft in the Ova; and that there is fuch a vaft Provision made thereof, becaufe of the Odds there are, whether one of fo many fhall ever find its Way into, and thro' fo narrow a Conveyance.

For in the *Corona imperialis*, where the Uterus or *Vasculum Seminale* of the Plant ftands upon the Centre of the Flower, from the Top of which ftands the Stylus; the *Vasculum Seminale*, and Stylus together, representing a Piftillum; round this are planted fix Stamina; upon the Extremities of each of thefe are Apices, fo artfully fixed, that they turn every Way with the leaft Blaft of Wind, being in Height almoft exactly equal to the Stylus, about which they play, and which in this Plant is manifefly open at Top; it is hollow all the Way, and upon the Top of the Stylus there is a Sort of Tuft, confifting of pinguid Villi, fuppofed to be placed there to catch and detain the Farina, as it flies out of its Thecæ; and that the Rain either wafhes it, or the Wind fhakes it down the Tube, till it reaches the *Vasculum Seminale*.

In the *Caprifolium* or Honey Suckle, there riles a Stylus, from the Rudiments of a Berry, into which it is inferted, to the Top of the monopetalous Flower; from the Middle of which Flower are fent forth feveral Sta-

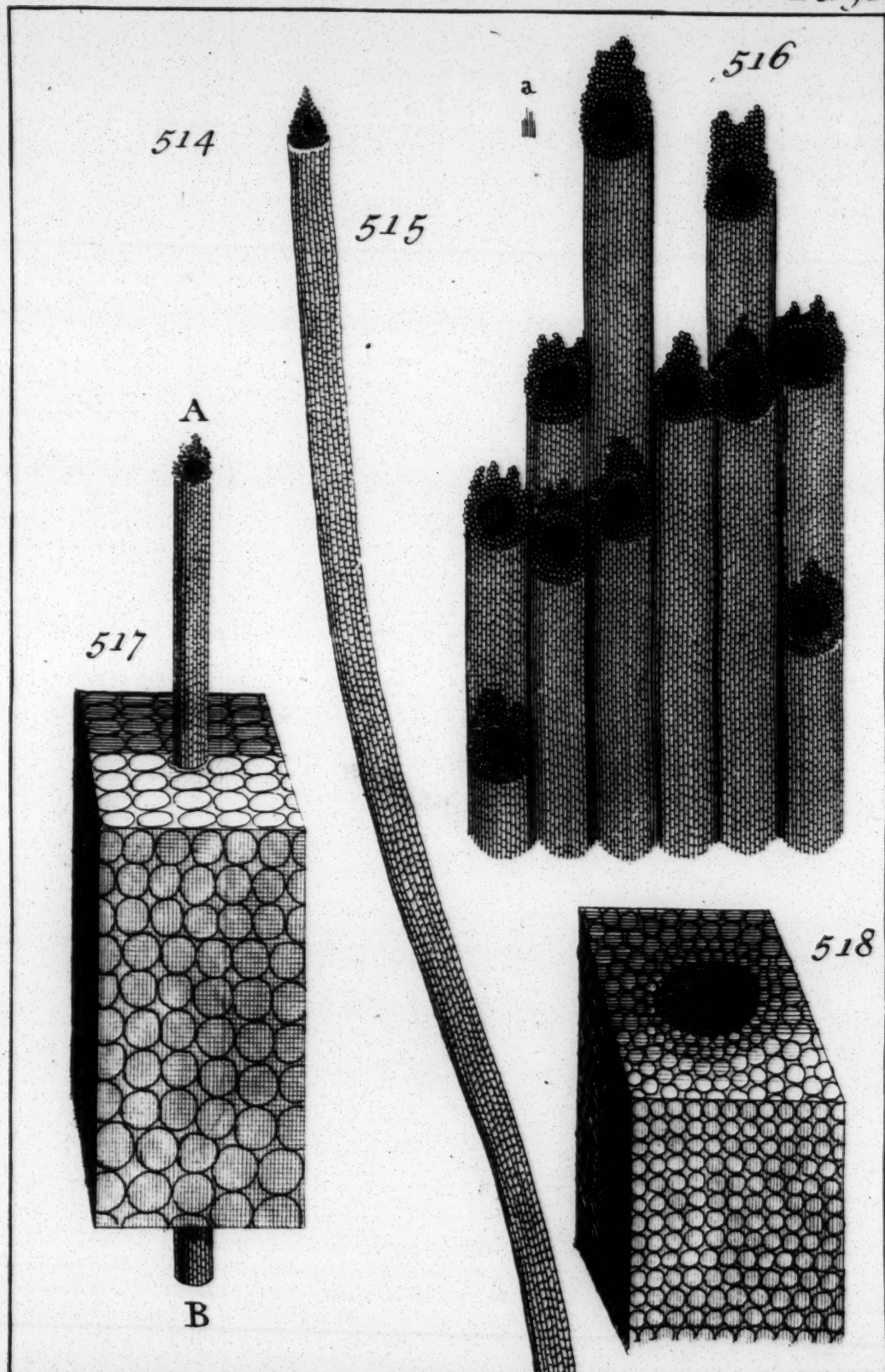
* *Phi. Tranf.* No. 287.

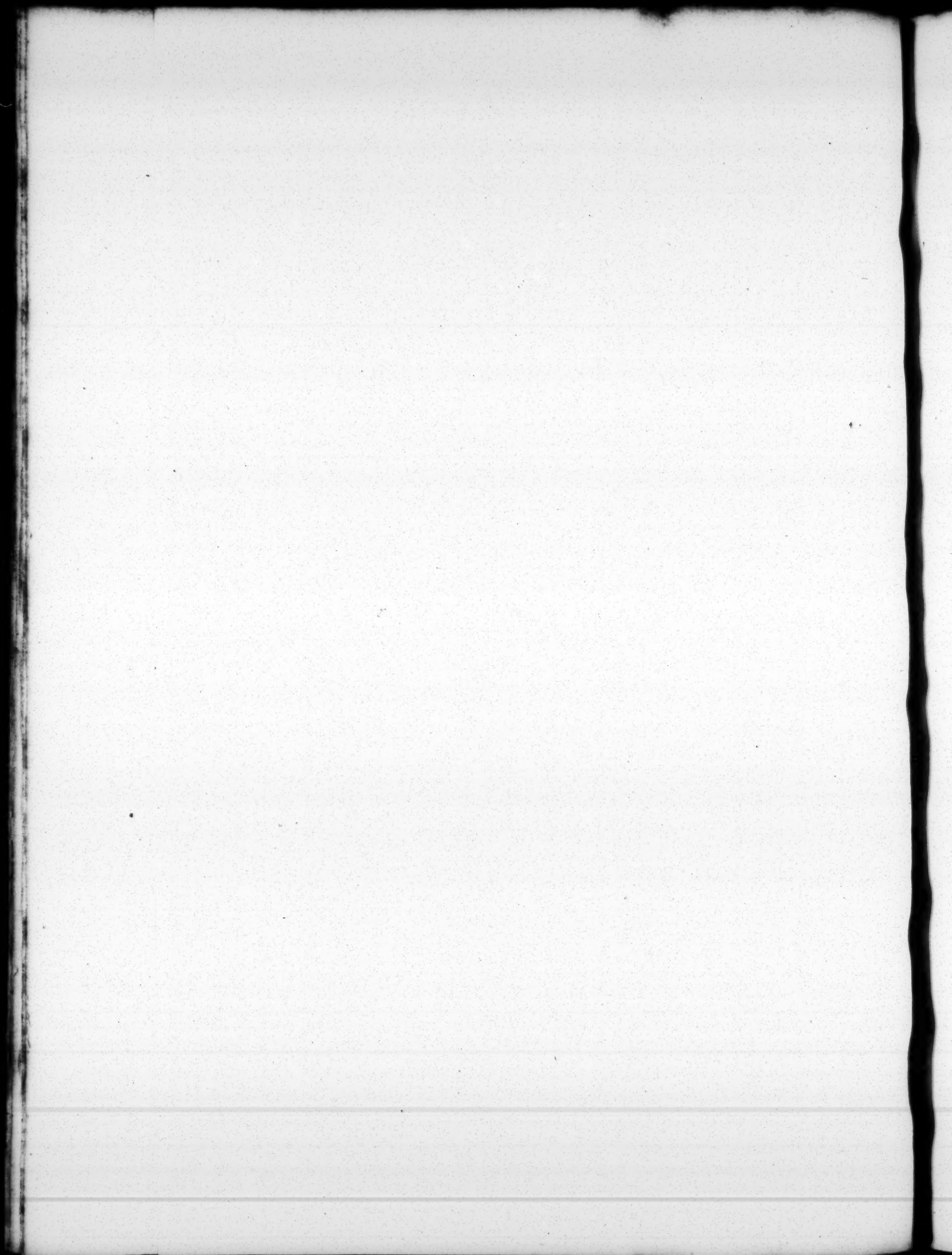
mina, that shed their Farina off the Cafes, upon the Orifice of the Stylus, which in this Plant is villous or tufted, upon the same Account as the former is.

In *Allium* or common *Garlick*, there arises a tri-coccous Uterus, or Seed-Vessel, in the Center of which is inserted a short *Stylus*, not reaching so high as the Apices, which thus overtopping it, have the Opportunity of shedding their Globules the more easily into its Orifice; for which Reason there is no Tuft on this as on the former, to insure its Entrance, that being provided for by its Situation just under them.

From whence we conclude, that where a fine Powder is curiously prepared, carefully repositied, and shed abroad at a peculiar Season, where there is a Tube planted in such a Manner, as to be fit to receive it, and such Care in disposing this Tube, that where it does not lie directly under the Cafes that shed the Powder, it hath a peculiar Apparatus at the Extremity to insure its Entrance, so that nothing can be more genuinely deduced from any Premises; than it may from these, that this Powder, or some of it, was designed to enter this Tube; if these *Stamina* had been only excretory Ducts, to separate the grosser Parts, and leave the Juice designed for the Nourishment of the Seed the more reserved, what Need was there to lodge these *Fæces* in such curious Repositories? They would have been convey'd any where, rather than where there was so much Danger of their dropping into the Seed-Vessel again, as they are here. Again the Tube over the Mouth of which they are shed, and into which they enter, leads always directly into the Seed-Vessel; to which may be added, that the Tube always begins to die, when these *Thecae* are emptied of their Contents; if they last any longer, it is only whilst the Globules which enter at their Orifice, may be supposed to have finished their Passage; nor can we expect a more convincing Proof of these Tubes being designed to convey these Globules, than that they wither when there are no more Globules to be conveyed.

In leguminous Plants, if the Petala of the Flower be carefully taken off, the Pod or Siliqua may be discovered, closely cover'd with an involving Membrane, which about the Top, separates into several *Stamina*, each being fraught with its Quantity of *Farina*; and these *Stamina* bound close upon the Brush, which is observable at the Extremity of that Tube, which here also leads to the Pod; it does not indeed stand upright, but bent so as to make almost a right Angle with it: In *Roses* there stands a Column consisting of several Tubes, clung closely together, tho' easily separable, each leading to its peculiar Cell, having the *Stamina* in great Numbers planted all round. In *Tithymalus* or *Spurge*, there arises a tricoccous Vessel, that, whilst it is small and so not easily discernable, lies at the Bottom, till it is impregnated; but afterwards it grows up and stands so high upon a tall Pedicle of its own, as would incline one to think, that there was to be no
Com-





Communication between this and the *Apices*, which he sees dying below. In *Strawberries* and *Rasberries*, the Hairs which grow upon the ripe Fruit are so many Tubes, each leading to its particular Seed; and therefore we may observe, that in the first opening of the Flower there stands a Ring of *Stamina* within the *Petala*, and the whole inward Area appears like a little Wood of these Hairs or Pulp, which when they have received and conveyed their Globules, the Seed swells and rises in a carnos Pulp.

Fig. 527. represents a yellow Lilly. A, the Top of the Pistil or Tube, at which the feminal Plants are supposed to enter, and through which they are conveyed to the unimpregnated Seeds in the Seed-Vessels; b b the *Apices Semini-formes*, which when open, shed that Powder which enters the Tube at A; C the Place of the Seed-Vessel at the Bottom of the Tube, the Tube and Vessel itself being concealed under the Leaf in this Figure.

Fig. 528. represents the *Siliqua* in a Flower of a Pea kind, E the Tube which arises from the *Siliqua*, and conveys the Plants thereto; F the membranous Coat which involves the *Siliqua* laid open; g g g g the *Apices*, which before the membranous Tegument is laid open, appear to rise from its Edges, and by the *Petala* of the Flower are kept close upon the Orifice of the Tube, that they may conveniently shed their Farina into it.

Hence we learn from the general Structure of the Flowers of Plants, though diversified infinite Ways, that some have no sensible Pistil, others no *Stamina*, others have *Stamina* without any *Apices*; and what exceeds all the rest, some Plants have no Flowers.

Mr. *Bradley* observes, that at the Bottom of the Pistil of the Lilly, there is a Vessel which he calls the *Uterus*, or Womb, wherein are three Ovaries filled with little Eggs, or Rudiments of Seed, which, says he, always decay and come to nothing, unless impregnated by the Farina of the same Plant, or some other of the same Kind.

It is this Farina or Dust falling out of the *Apices* on the Pistil, fecundifies the Grain or Fruit inclosed therein; and hence they call it the *Farina fecundans*. Thus the Farina should be the male Part of the Plant, and the Pistil the female.

The Fruit is usually at the Basis of the Pistil, so that when the Pistil falls with the rest of the Flower, the Fruit appears in its Stead. The Pistil is frequently the Fruit itself, but still they have both the same Situation in the Center of the Flower, whose Leaves disposed around the little Embrio, only seem destined to prepare a fine Juice in their little Vessels for its Support. Mr. *Bradley* imagines their Use to be only to defend the Flower.

The Disposition of the Pistil, and the *Apices* about it is always such, as that the Farina may fall on its Orifice; it is usually lower than the *Apices*; and when we observe it to be grown higher, we may conjecture the Fruit has begun to form itself, and has no further Occasion for the male Dust. Also, as soon as the Work of Generation is over, the male Parts, together

with the Leaves, fall off, and the Tube leading to the Uterus begins to shrink. Nor must it be omitted, that the Top of the Pistil is always either covered with a Sort of Velvet Tunicle, or emits a gummy Liquor, the better to catch the Dust of the Apices. In Flowers that turn down, as in the *Acanthus*, *Cyclamen*, and the *Imperial Crown*, the Pistil is much longer than the Stamina; that the Dust may fall from their Apices in sufficient Quantity thereon.

This System favours much of that admirable Uniformity found in the Works of Nature, and carries with it all the seeming Characteristicks of Truth. Mr. *Geoffroy* says, that the Plant is rendered barren, and the Fruits become abortive, by cutting off the Pistils before the Dust could impregnate them, which is since confirmed by other Experiments of Mr. *Bradley*.

In many Kinds of Plants, as *Willow*, *Oak*, *Pine*, *Cypress*, *Mulberry Tree*, &c. the Flowers are sterile, and separate from the Fruit; but then they have their Stamina and Apices, which may easily impregnate the Fruits, which are not far off.

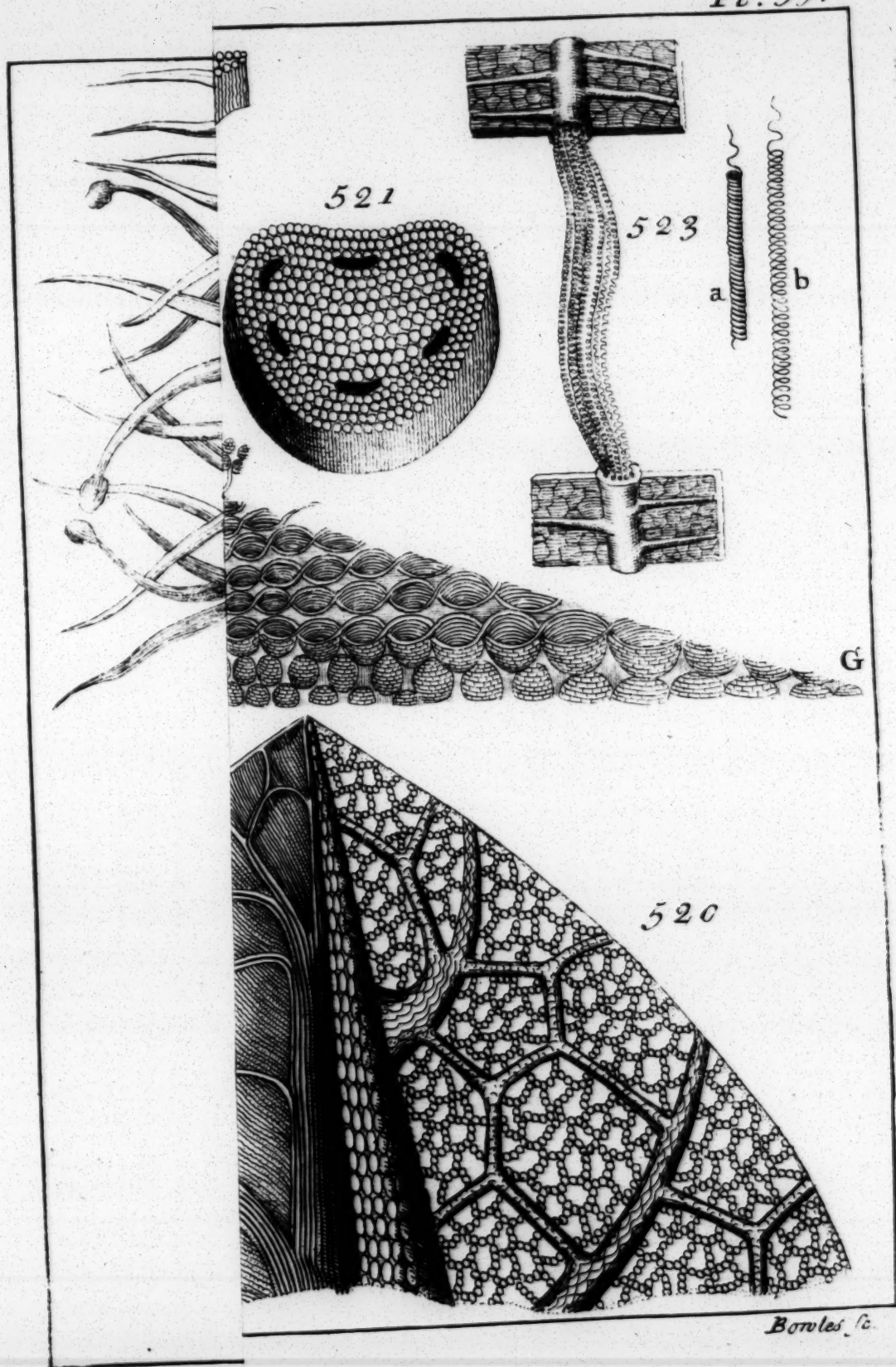
There is some Difficulty in reconciling this System to a Species of Plants, which bear *Flowers* without *Fruits*, and another Species of the same Kind and Name, which bear *Fruits* without *Flowers*; hence distinguished into Male and Female; of which Kind are the *Palm-Tree*, *Poplar*, *Hemp*, *Hops*, &c. for how should the Farina of the Male here come to impregnate the Seed of the Female. Mr. *Tournefort* imagines, that the fine Down always found on the Fruit of these Plants, may serve instead of Flowers, and do the Office of Impregnation; but Mr. *Geoffroy* rather takes it, that the Wind doing the Office of a Vehicle, brings the Farina of the Males to the Females.

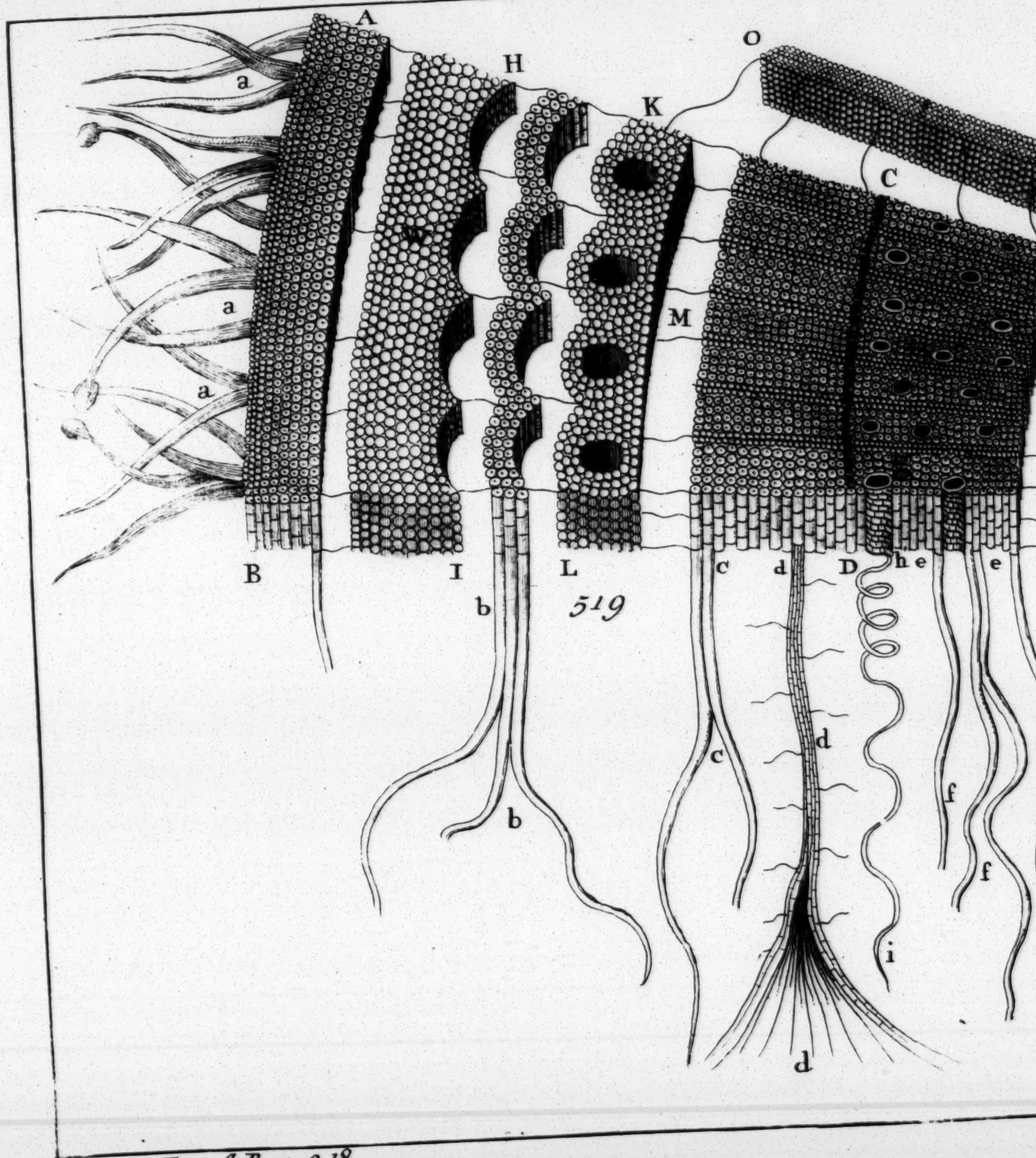
For the Manner wherein the Farina fecundifies, Mr. *Geoffroy* advances two Opinions, 1. That the Farina being always found of a sulphurous Composition, and full of subtile penetrating Parts, falling on the Pistils of the Flowers, there resolves, and the subtilest of its Parts penetrating the Substance of the Pistil and young Fruit, excite a Fermentation sufficient to open and unfold the young *Plant*, contained in the Embrio of the Seed; in this Hypothesis the Seed is supposed to contain the Plant in Miniature, only wanting a proper Juice to unfold its Parts and make them grow.

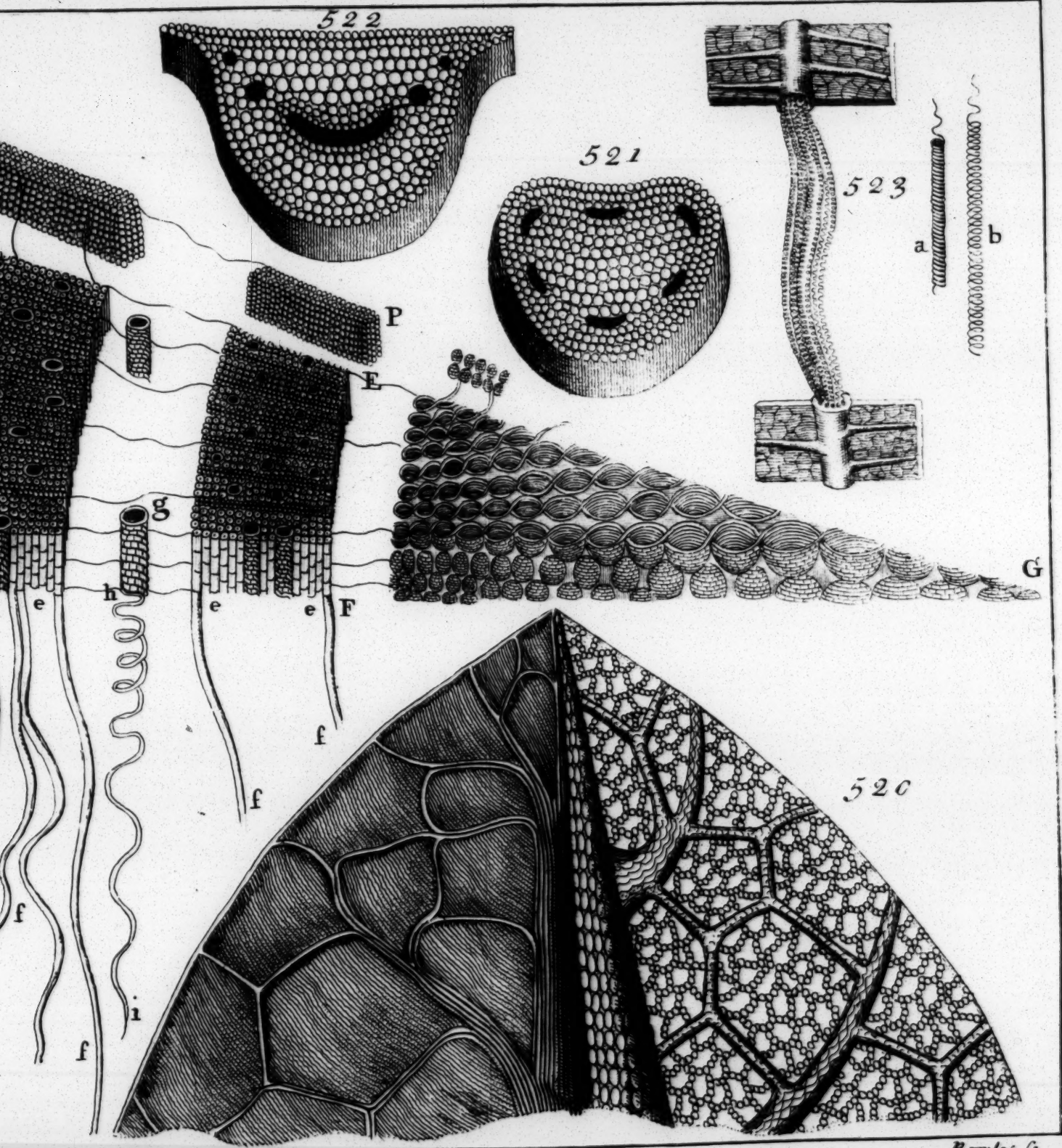
The second Opinion is, that the Farina of the *Flower* is the first Germ, or Bud of the new Plant, and needs nothing to unfold it, and enable it to grow, but the Juice it finds prepared in the Embrio's of the Seed.

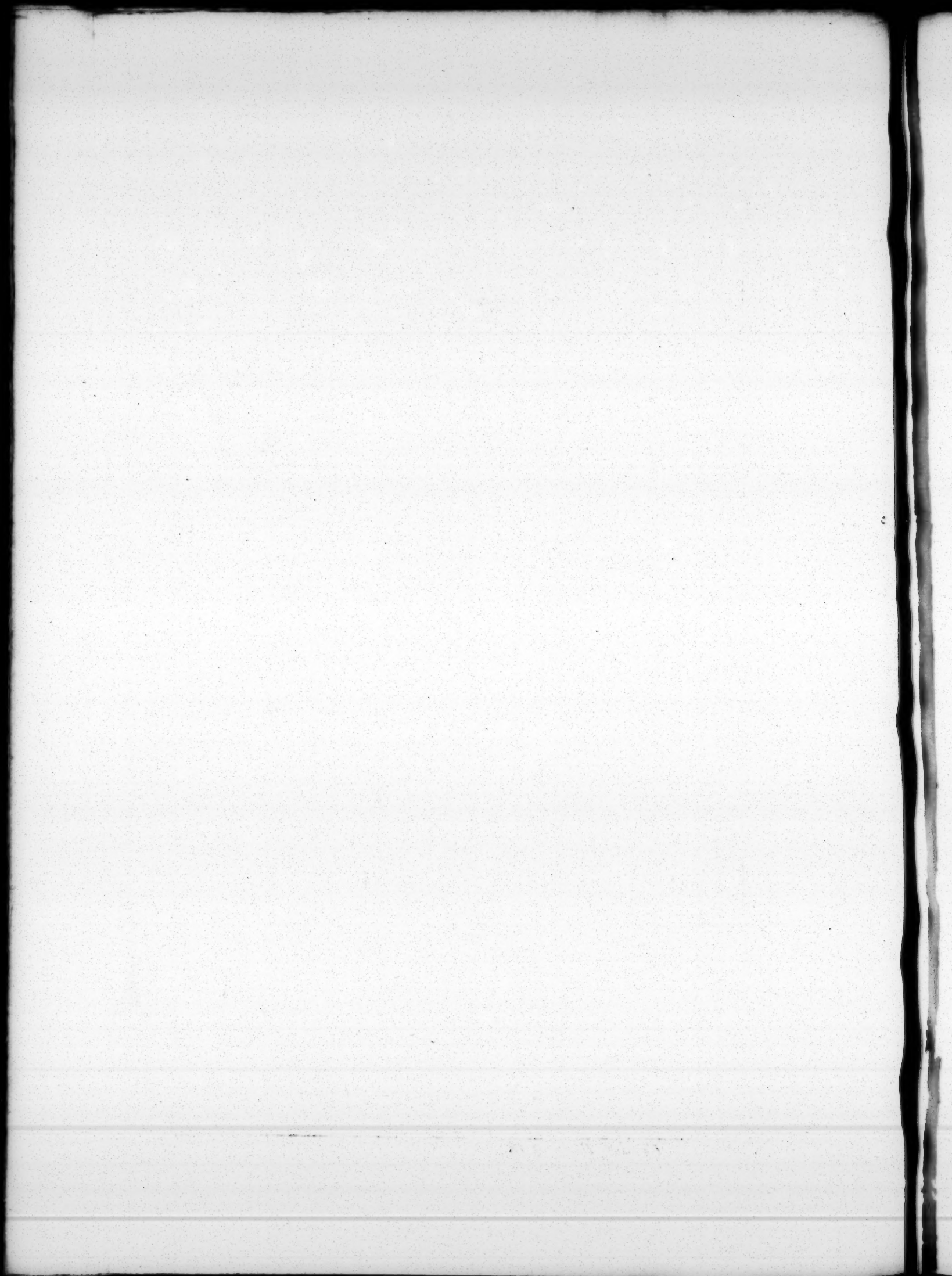
The Reader will here observe, that these two Theories of *vegetable Generation*, bear a strict Analogy to those of *Animal Generation*, viz. either that the young Animal is in the *Semen Masculinum*, and only needs the Juice of the Matrix to cherish and bring it forth, or that the Animal is contained in the *Female Ovum*, and needs only the Male Seed to excite a Fermentation.

Mr.









Mr. *Geoffroy* takes the proper Seed to be in the Farina, because the best *Microscopes* do not discover the least Appearance of any Bud in the little Embrio's of the Grains, when examined before the Apices have shed their Dust.

In leguminous *Plants*, if the Leaves and Stamina be removed, and the Pistil, or that Part which becomes the Pod, be viewed with the *Microscope*, ere yet the Flower be opened, the little green transparent Vesiculæ, which are to become the Grains, will appear in their natural Order, but still shewing nothing else but the mere Coat or Skin of the Grain.

If the Observation with the *Microscope* be continued for several Days successively, in other Flowers as they advance, the Vesicula will be found to swell, and by Degrees to become replete with a limpid Liquor; wherein when the Farina comes to be shed, and the Leaves of the Flower to fall, we observe a little *greenish Speck*, or *Globule*, floating about at large. At first there is no Appearance of Organization in this little Body; but in Time, as it grows, we begin to distinguish two little Leaves like two Horns. The Liquor insensibly diminishes as the little Body grows, till at length the Grain becomes quite opake; when upon opening it, we find its Cavity filled with a young Plant in Miniature, consisting of a *Plumula*, *Radicle*, and *Lobes*.

The Tops or Apices sometimes stand erect above their Chives or Stamina, as those in *Lark-beel*, but generally hang a little down by the Middle like a *Kidney Bean*, as in *Mallows*, they have for the most Part a double Cleft, tho' it is in some single, from which they disburse their Powders, which start out, and stands upon the Lips of the Cleft, as at Fig. 529. which represents one of the Apices of the Flower of *St. John's Wort* magnified.

The Particles of these Powders altho' like Meal or Dust, yet if viewed thro' a Microscope, they have all of them very curious and regular Forms. In *Dog's-Mercury* and *Borage* they are extreamly small, but in *Mallows* fairly visible to the naked Eye. In some Flowers these Powders are yellow, as in *Dogs-Mercury*, *Goats Rue*, &c. And in some of other Colours, but in most they are white; those of *yellow Henbane* are very elegant, being to the naked Eye as white as Snow, and in the *Microscope* as transparent as Crystal.

The *Tops* or *Apices* which contain the Farina, are for the most Part either white or yellow, sometimes blue, but never red, whatever Colour the Flowers be of. They differ in Position, sometimes standing double upon one Chive, as in *Toad-Flax*, *Snap-Dragon*, &c. In some they are fastned to their Stamina at their Middle, as in *Spanish Broom*, *Hyssop*, *Scabeous*, *Beben*, &c. in some erect, as in *Clematis*, *Austriaca*, *Ladies Looking-Glass*, *Rape-Crow-foot*, &c. *Coded Arsmat* hath no Chives, but stand upon a large Base.

Their Number are also different, in great *Celandine*, *Rose*, *Rape-Crow-foot* they are numerous; in great *Plantain*, and some other Herbs, much

more conspicuous than the Foliature itself. In *Germander Chickweed*, they are always two, and no more; in some they follow the Number of the Leaves, especially in the Number five; as in *Blattaria*, *black Henbane*, &c. In *Stickwort* and *Lychnis sylvestris* they are ten, just double to the Number of Leaves.

Their Shape is different, and always very elegant, with great Variety. In *Borage*, like the Point of a Spear; in *Blattaria*, like an Horse-shoe; in *Clematis* like a Spatula, wherewith Apothecaries make their Mixtures: In *Mallow* like a Head-roll; in *Hyssop* they have one Cleft before, in *Blattaria* one round about; in *Water Betony* one at the Top; in *Scabious* they have a double Cleft, one on each Side.

In *Colocynthis* the Farina is not contained in several Thæcæ or Apices standing upon Chives, but is all of one entire Part, like a thick Column in the midst of the Flower, having several little Ridges or Furrows winding from the Top to the Bottom round about, in the Middle of each of which runs a Line, where the Skin, after some Time, opens into two Lips, and presents the globular Particles contained in the Hollow of every Ridge.

But where the Seeds are contained in the Apices, a Stilus or little Column stands upon the Top of the true *Seed-Case*, which is also regularly and variously figured. In *Bind-weed* it hath a round Head like that of a great Pin. In the *common Bell*, *St. Johnwort*, &c. it is divided into three Parts. In *Gerarium* into five; in *Asarum* into six, sometimes the Head is smooth, and in others it is beset with little Thorns, as in *Hyoscyamus*.

The Pistil is a little upright Part in the Middle of the Calx, or the Leaves of *Flowers*, called also the Style.

It is an essential Part of a Flower, and the principal female Organ of Generation, it being in this that the Seeds or young Plants are formed. It arises from the Pedicle of the Flower, or the Center of the Calx, and at length becomes the young Fruit, which is sometimes hid in the Calx, and sometimes quite out.

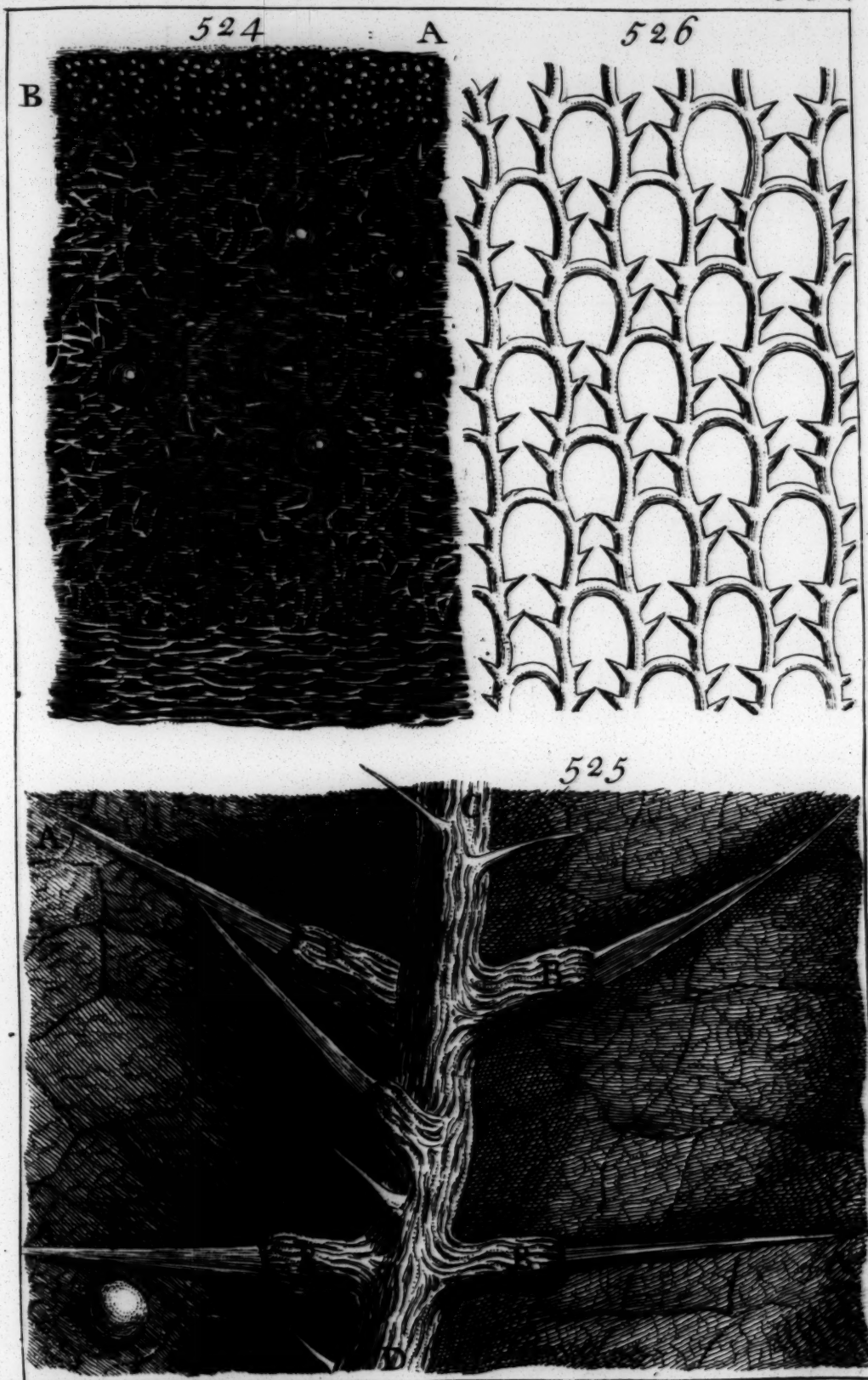
Its Figure is very different in different Flowers; in some it is a little Stalk, which enlarges at the two Ends, in others a mere Stamen or Thread, sometimes it is round, sometimes square, triangular, oval, &c.

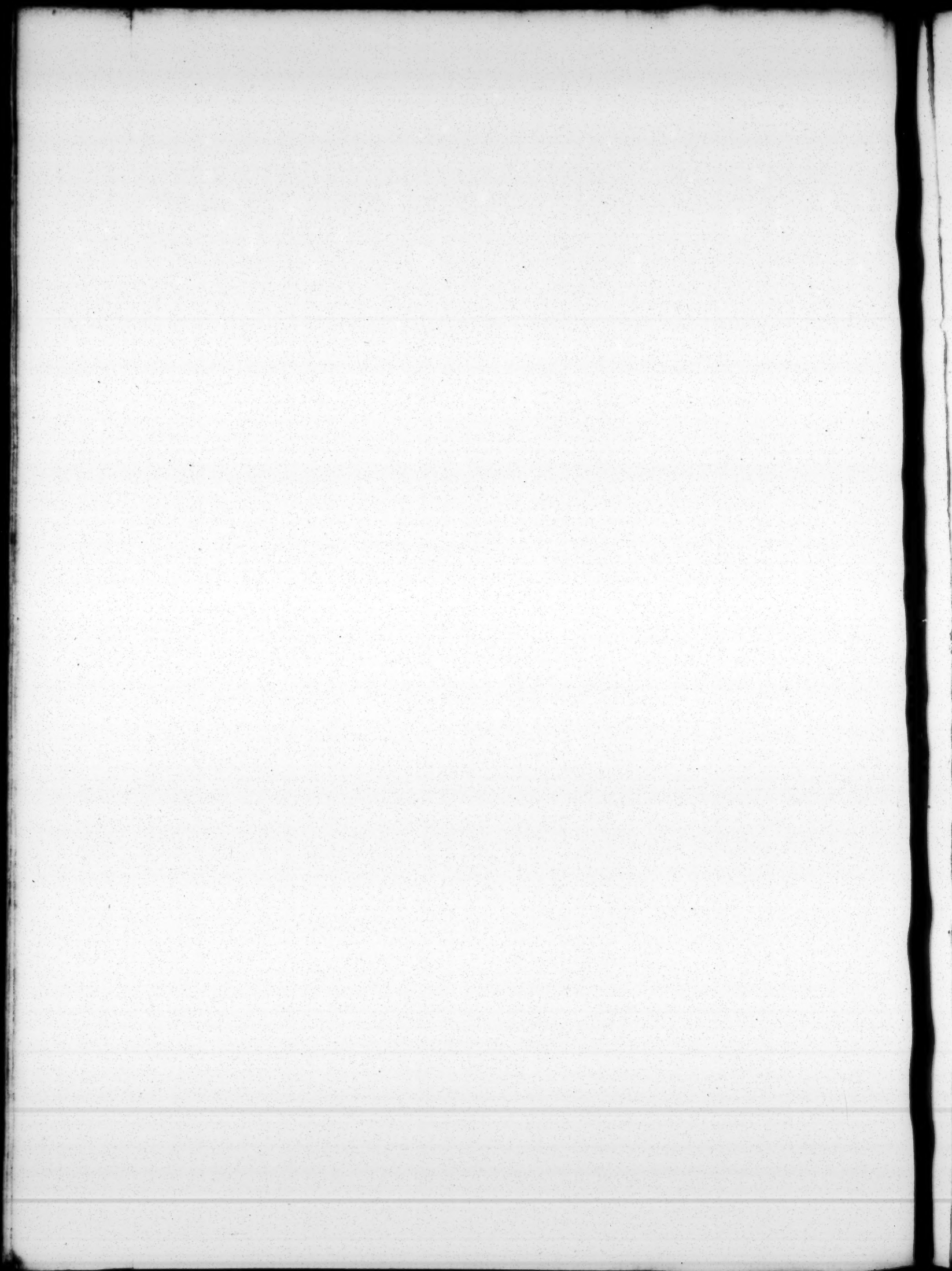
Almost all Pistils are furnished at Top, either with fine Hairs, or little Filaments disposed in Plumes, or are beset with little Vesicles full of a glutinous Juice.

Some Flowers have several Pistils, or rather the Pistils terminate in several Branches, which have their Rise from as many young Fruits, or as many Capsulæ containing Seeds.

Whatever Form the Pistils are in, they have certain Apertures at their Tops, or Clefts, continued their whole Length, to the Base or Embrio of the Fruit.

The Seed Vessels consists sometimes of two, and for the most part of three





three Pieces ; for which Reason they are called Suits, as at a b c d, Fig. 527.

The outer Part of each Suit, according to *Grew*, is its Floret, whose Body or Tube is divided at the Top (like that of a Cowslip) into five Leaves as at b, which forms a Flower in Miniature, and is all the Flower in many Plants, as *Mugwort*, *Tansie*, &c. Upon the Expansion of the Floret, the next Part c, of the Suit begins to appear from within its Tube, which may be called the Sheath (with respect to that within it). This Sheath in a short Time divides at Top, through which Aperture the Blade d displays itself. This is the third Part of the Suit, and terminates in a forked Point, about which appears little Globules.

In some Flowers every one of the before-mention'd Florets is encompassed with an Hedge of Hairs, and every Hair branched on both Sides, almost like a Sprig of Fir, as at c d in golden Rod, Fig. 530. which shews one of the Suits thereof as it appeared in the *Microscope*, in which at e is the little Column or Blade that contains the Farina, which is also seen by itself at F.

The Base of the Floret is generally cylindrical, but sometimes square, as in *French Marigold*, at a, Fig. 531. and the Leaves thereof, which for the most part are smooth, in the same Flower are all over hairy. The middlemost of the three Parts or Sheath b, is usually fastned to the Top, or else at the Bottom of the Floret, and is rather indented than parted into Leaves : The Surface seldom plain or even, but wrought into five Ridges and as many Gutters, running almost parallel from Top to-Bottom.

The inmost Part or Blade runs through the Hollow of the two former as at a, Fig. 531. and is fastned with the Floret to the Convex of the Seed Case ; the Head and Sides of this Part is always beset round about with Globulets. In some growing close to the Blade, as in common Marigold ; and in the *French Marigold*, as at Fig. 532. and others, upon little slender Stalks. These, as the Blade springs up from within the *Sheath*, are rubbed off and stands like a Powder upon them both. In some, as in *Chicory*, they seem to grow within-side the Sheath, as will appear if it be split * with a small Pin, as also in *Knapweed* they are very numerous.

The Head of the Blade is always divided into two, and sometimes into three Parts, as in *Chicory*, Fig. 533. which gradually curl outwards after the Manner of Scorpion Grass.

This Description agrees principally to the corimbiferous Kind, as *Tansy*, *Camomile*, &c. but in *Scorzonera*, *Chicory*, Fig. 533. *Hawk-weed*, *Moufe-ear*, and all the intibous Kind, with many more. The Pistil is separated from the Foliature, so as to stand alone therein, every Leaf a b c of the Flower having a Pistil of its own ; for which Reason the Base of each Leaf is formed into a little Tube a, Fig. 533. that incloses the Pistil, which commonly consists of

* *Grew An. Plants*, p. 170.

a Sheath and Blade e; the Leaf itself answering to the Floret in other Flowers. The Blade (or rather Stamina) is seen drawn out of its Sheath at fg of the same Figure, and at g the Head of the Blade is open'd into three Parts, which are full of those globular Particles before-mention'd.

The Time in which the *Flower* is generated, is hardly any where, if at all taken Notice of among so many Observers of Plants. It is therefore to be remarked, that all the Parts of the Flower in all Flowers, are perfectly finished long before they appear in Sight, usually three or four Months, and in some six. And that in Perennial Plants, those Flowers which appear in any one Year are not formed in that, but were actually in Being and intire in all their Parts the Year before. The Flower of *Mezeron*, which opens in *January*, is intirely formed about the Middle of *August* in the foregoing Year; at which Time, if the green Leaves of the Bud be carefully removed, the Leaves of the Flower and Seed-like Attire, encompassing the Seed-Case, may be distinctly seen when placed before the *Microscope*.

In order to observe the mealy *Powder* or *Farina*, let it be gathered in the midst of a Sun-shiny Day when all the Dew is off, shake, or else gently brush it off with a soft Hair-Pencil upon a clean Piece of white Paper; then breathe upon a single Talc, and instantly apply it to the *Farina*, which will adhere to it. If too great a Quantity of Powder sticks to the Talc, blow a little of it gently off, if not enough breathe on it again, and touch the *Farina* with it as before, then fix it in a Slider as before directed.

But I would here advise the Curious not to neglect an Examination of the little Cells that contain the *Farina*, and also of the Pistils and Uteri, and other Parts of Generation of the *Flowers*.

Fig. 534, represents the Flower of St. Johnwort a little magnified, in which may be seen the Stamina and their Apices surrounding the Seed-Case. Fig. 529, is one of the Apices more magnified.

Fig. 530, represents one Suit of golden Rod Flower, consisting of a Seed-Case A, and a Stamina e, one of which is seen by itself at F.

Fig. 531, shews one of the Suits of *French Marigold*, or *Flos Africanus* magnified, of which there are about 12 in one Flower, each consisting of three Pieces, the middlemost of which is seen alone at Fig. 532.

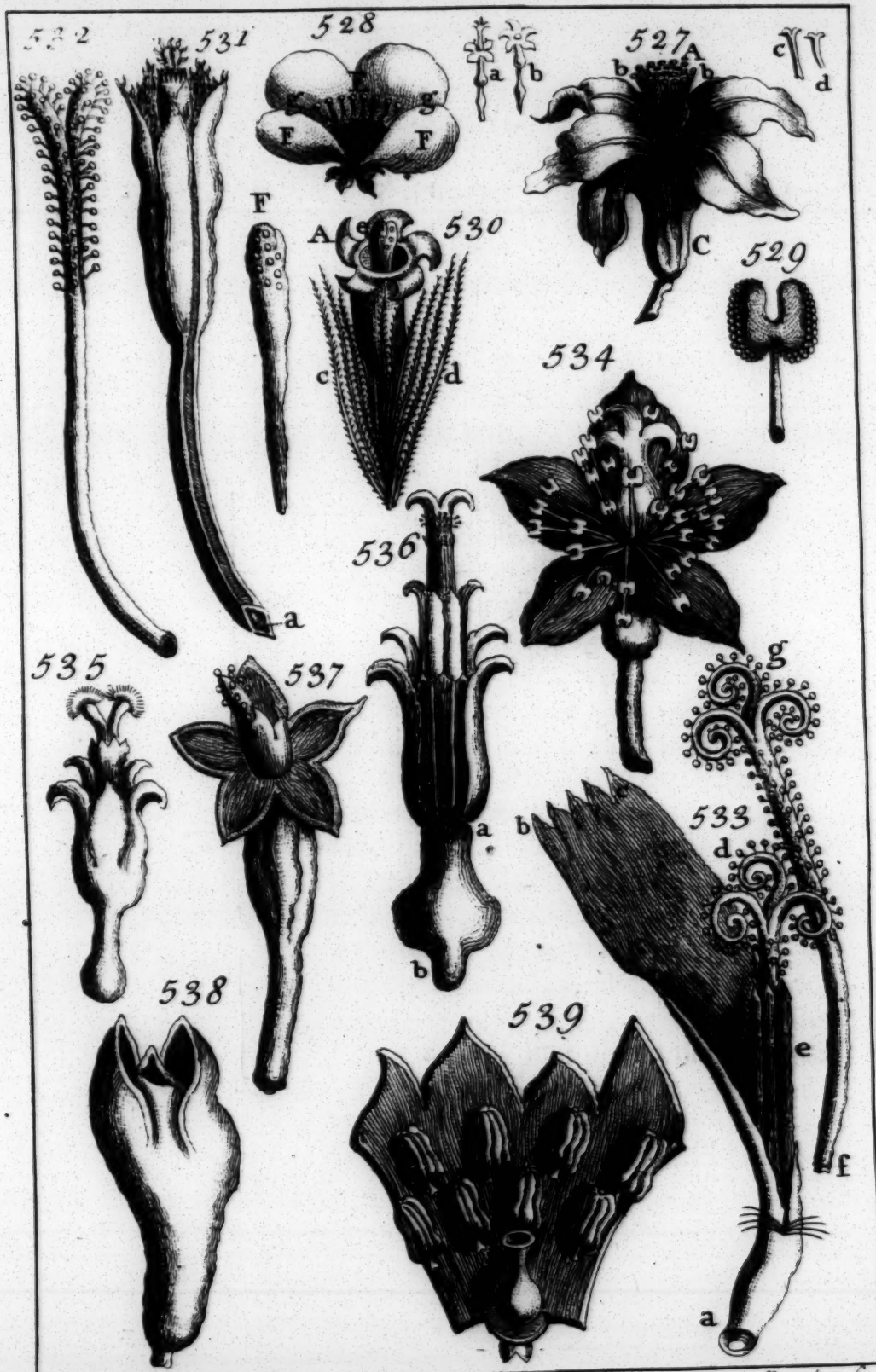
Fig. 535, represents one Suit of *Chrysanthemum-Creet*, consisting also of three Pieces, of which there are about 80 in one Flower.

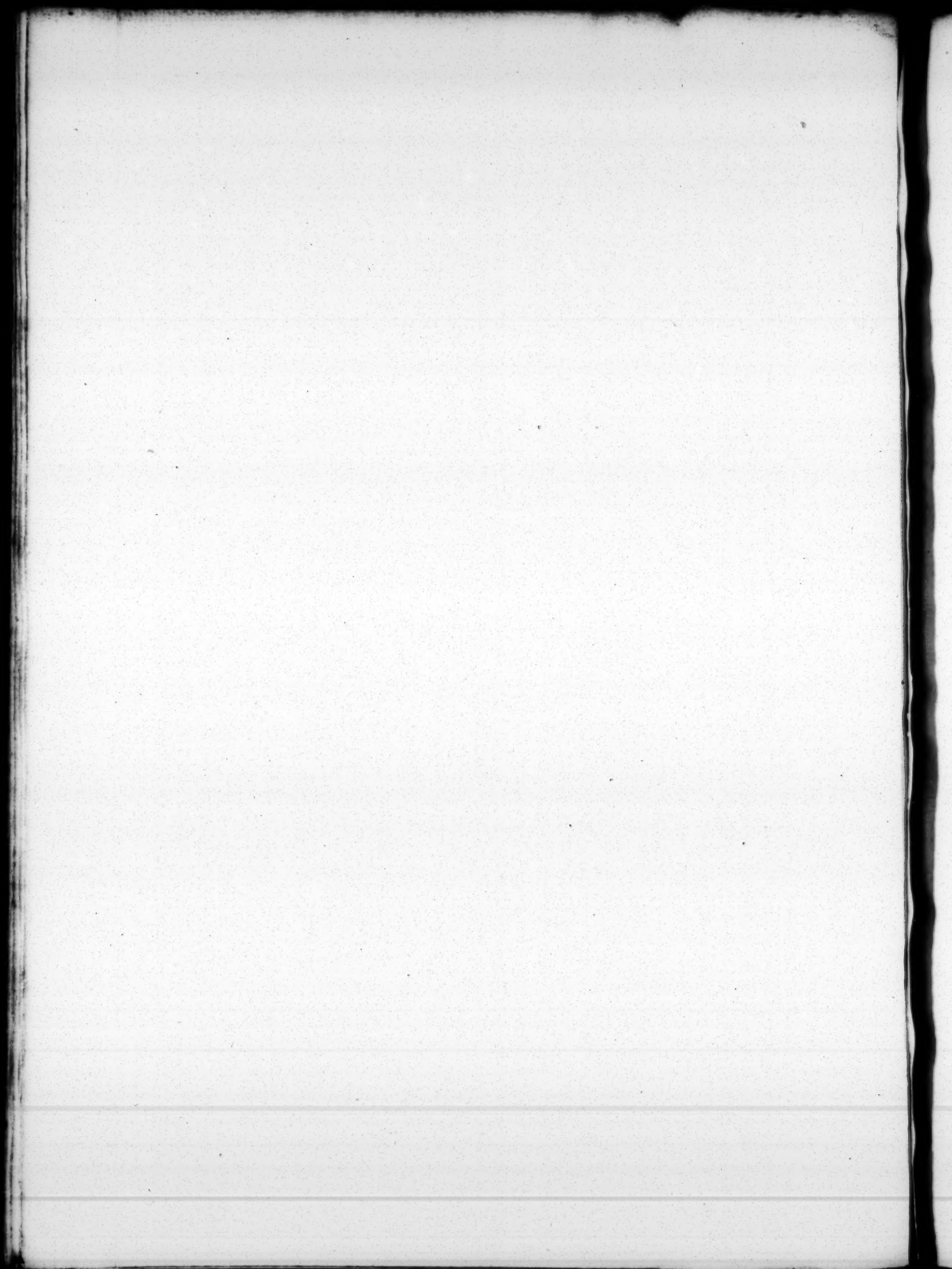
Fig. 536, exhibits one Suit of *Knapweed* magnified, consisting of three Pieces, a b is the Seed-Case, at the Bottom of every Suit.

Fig. 537, is a microscopick Representation of one of the Suits of a *Marigold*, of which there are about 40 in one Flower.

Fig. 533, represents the Pistil and Blade, proper to each Leaf in the Flower of *Chicory*.

Fig. 538, represents one of the Flowers in the Bud of *Mezeron* perfectly formed





formed in all its Parts the Year before it appears, but differs in Shape as a Foetus doth when newly formed.

Fig. 539, shews the same Flower cut open, wherein may be seen the spermatick Thæcæ and the Uterus.

C H A P. XL.

Of the Fruit of an Apple, Lemon, Cucumber, and Pear.

S E C T. I.

THE general Composition of all *Fruit* is one, that is, their essential Parts are in all the same, and but a Continuation of those which have been already observed in the other Parts of a Plant. Yet from the different Constitutions and Tinctures of those Parts, the several Varieties in Fruits proceed.

An *Apple* consists of a Skin, Parenchyma, Vessels and Core, the Parenchyma or Pulp is the same with that of the Bark of the Tree, as is apparent not only from the visible Continuation thereof, from the one through the *Stalk* into the other, but also from their Structure, being both composed of Bladders, with this Difference, that whereas in the Bark they are very small and spherical (as may be plainly seen when viewed through the *Microscope*;) here they are oblong and very large, in Proportion to the Size and Tenderneſs of the *Fruit*, being all uniformly stretched out by the arching of the Vessels, from the Core towards the Circumference of the Apple.

The Vessels, as in the other Parts of a Plant, are succiferous, and for Air, both the Branches of the former and the single Vessels of the latter are extremely small, running every where together; not collateral, as Veins and Arteries do in Animals, but the latter sheathed in the former.

They are distributed into twenty principal Branches, the ten outermost a little within the Apple, are diverted from a straight Line into so many Arches; from which a few small Branches are without any Order dispersed through the Apple; the five middlemost and the five inmost run in a straight Line as far as the Core, and are there distributed into as many lesser Arches, the former at the outer and the latter at the inner Angles of the Core, upon which last the Seeds hang.

All these main Branches meet together at the Top of the *Apple*, where originally they all ran into the Flower.

A *Lemon* hath a three-fold Parenchyma, seemingly derived from each other; the Texture upon every Derivation being somewhat altered, by being made more close and elaborate. The outmost called the Rind, hath the most open and coarseſt Texture, being composed of the largest Threads,
and

and these wove up into larger Bladders. Those little Cells which contain the essential Oil of the Fruit, and stand near the Surface of the Rind, are some of the same Bladders, but more dilated.

From this outmost Parenchyma, nine or ten Insertions are produced, betwixt as many Portions of the pulpy Part towards the Center, where they all unite into one Body, answerable to the *Pith* in the *Trunk* or *Root* of the *Tree*; and are a conspicuous Demonstration of the Communication between the *Bark* and *Pith*.

Throughout this Parenchyma the Vessels are dispersed, but the chief Branches stand on the inner Edge of the Rind, and the outer Edge of the Pith, just at the Extremities of every Lamellæ from those Branches at the Edge of the Pith; other little and very short ones shoot into the Pulp of the *Fruit*, upon which the Seeds are appendant. In the Center of the Pith are eight or nine in a Ring, which run through the Fruit up to the Flower.

Between the Rind and Pith, and those several lamelated Insertions which join them together, stands the second Sort of Parenchyma, being closer and finer, and divided by the Lamels into several distinct Bodies, every one of them being an entire Bag; in every one of which the third Parenchyma is contained; which is also a Cluster of other lesser Bags, all disjoined from one another, each having their distinct Stalks of several Lengths, by which they are all fastned to the utmost Side of the great Bag wherein they are contained. Within these lesser Bags also the *Microscope* can shew many Hundreds of Bladders, consisting of extremely fine Threads, as it were wove together into that Figure; and within these Bladders lies the acid Juice of the Lemon.

A *Cucumber* hath also a three-fold Parenchyma, the outermost is derived from the Bark, which being exposed for some Time to dry, and then transversely cut with a Razor; not only the Bladders but also the Threads whereof the Bladders consist, are plainly visible when viewed through the Microscope.

Throughout this Parenchyma are dispersed the Sap Vessels, in ten or twelve very large Branches, each of which embosoms another of Air Vessels.

The middle Parenchyma is derived from the Pith, and divided into three triangular Columns, within which are a distinct Sort of Sap Vessels, whence several small and short Fibres shoot into the inmost Parenchyma, whereupon the Seeds do hang.

The inmost Parenchyma wherein the Seeds do lie (and which answers to the Pulp of a *Lemon*) seems to be produced from the Seed-fibres, by three Insertions from the Columns, and as many from the outmost Parenchyma, and these reinserted; it is divided into six triangular Bodies, and every Triangle into three Ovals.

A *Pear*, besides the Skin, consists of a two-fold Parenchyma of Vessels,

tartareous Knots, or Grains, and a Core; the Skin when viewed in the *Microscope*, appears to be lined with a great Number of these tartareous Grains, which are also dispersed round about the Fruit, for about the Thickness of the Third of an Inch, as will appear on applying a transverse Slice of a Pear to the *Microscope*.

The outer Parenchyma is of the same Original and general Structure as in an Apple, but the Bladders not altogether so long with respect to their Breadth.

The Bladders here have also a different Position from that they have in an Apple, being in that all stretched out towards one common Center, which is that of the Apple itself. But here they every where bear a Respect to the said tartareous Grains, every Grain being the Center of a certain Number of Bladders.

Throughout this Parenchyma, the *Vessels* for Sap and Air are likewise dispersed into fifteen principal Branches. The five utmost make as many Arches, but commonly not so deep as in an *Apple*; from these some small Fibres are dispersed throughout the Parenchyma. The ten inner Branches proceeding to the Seed, and from thence with the other five to the Flower.

Next the Core stands the inner Parenchyma, consisting of small roundish Bladders, answerable to that of the Pith, from which it seems to be derived.

Between this and the outer Parenchyma, the said tartareous Grains begin (first) to stand nearer together, to grow bigger, and of a more unequal Surface; and by Degrees to unite into a Body, in some *Pears*, and especially towards the Cork, they are almost as hard as a Plumb-Stone.

On cutting a Pear lengthwise, through its Center, these tartareous Grains will be apparent.

At the Bottom of the Core in most Pears, and a little below the Center of the Fruit, is a Kind of umbelical Knot; from whence extends a streight Channel, which opens at the Middle of the Cork or Stool of the Flower, scarce wide enough to admit the smallest Pin.

S E C T. II.

Of a Plumb, and some other Fruits of the same Kind.

A *Plumb* consists of a Parenchyma, the two general Kind of Vessels, and a Stone; and in Proportion to the Bulk of the Fruit, hath more Vessels than an *Apple* or *Pear*. Also in *Plumbs*, all these Vessels are braced together into one uniform Piece of *Net-Work*, every where terminating at an equal Distance from the Circumference, the Skin is fibrous and tough.

The Stone is composed of two, or rather three distinct Parts, one of them the Lining, taking its Rise from the Parenchyma, which the Seed Branch

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brings

brings along with it, through the Channel in the Side, and at last into the Hollow of the Stone, and is there spread all over it.

The Foundation or Ground of the outer and more bulky Part of the Stone, is the inner Part of the Parenchyma, upon which the tartareous Parts of the Sap are continually precipitated, and thereby petrified, as appears on comparing the several Ages of the same Fruit together; on the Surface of many Stones, some of the said tartareous Parts appear in distinct *Grains*.

An *Apricock* is of the *Plumb* Kind, but some Things are herein better observed, as first the Position of the Bladders of the Parenchyma; for the tartareous Parts of the Sap, not being here dispersed in little Grains, throughout the Fruit as in a *Pear*, but are all thrown off into the Stone; therefore the Bladders all radiate exactly to the Center of the Stone, conveying thereto the feculent Sap, in so many little Streams. This is best seen when the Fruit is full ripe.

The gradual Transmutation of the inner Part of the Parenchyma into a Stone, is also more apparent in this Fruit, and so are the three Coats which serve for the Generation of the Seed; being now all very distinct and remarkable.

A *Peach* hath a much bigger Stone, and therefore when full ripe, it hath a more defecated or better refin'd *Juice*; the Reason why the Stone is so great, is because the Vessels run so numerously through the Body of it; and so cause a more copious Perspiration of the Lees therein.

A *Cherry* is likewise nearly related to a *Plumb*, but the Bracement or Reticulation of the Vessels, is here carried on farther, so as to be all round about contiguous to the Skin.

A *Walnut* is a *Nuciprune*, or between a *Plumb* and a *Nut*, for the Rind answers to the Pulp, and the Shell, as the Stone, is also lined; but the *Seed-Vessels*, which in a *Plumb* run thro' a Channel, made on Purpose in the Stone, do here enter as in a *Nut*, at the *Center* of the Shell; by which Means they are invested with a more fair Parenchyma.

S E C T. III.

Of the Grape.

A *Grape* is as it were a *Plumb* with two Stones, for their Thickness are as hard as any other. The principal Fibres run directly between the Stones; and the smaller Fibres, and make only one single *Net*; near the Circumference they all meet together at the Top of the *Grape*. Many lig-nous Fibres are also mixed with the Skin itself, whereby it becomes very thick and tough.

The Parenchyma, or Pulp of a *Grape* seems to be derived from the Pith, at least as far as the Reticulation of the Fibres.

C H A P. XLI.

The Anatomical Preparation of Vegetables.

THose *Leaves* of *Plants* are only fit for this Purpose, whose internal Structure is compos'd of woody Fibres, and are of a pretty good Thickness, as the *Leaves* of *Oranges*, *Lemons*, *Jessamin*, *Bays*, *Roses*, *Cherries*, *Apricocks*, *Peaches*, *Plumbs*, *Apples*, *Pears*, *Poplars*, *Pines*, *Oaks*, *Ivy*, &c.

There are several other that have no woody Fibres or Veins, but these dissolve without separating, as those of *Vines*, and *Lime-Trees*.

The *Leaves* are to be gather'd * in *June*, or *July*, when they are full grown, and have not been damaged by *Worms*, or *Caterpillars*; put them into an earthen Pot or large Glass, with a good deal of *Rain-Water*. The Pot or Glass being kept uncover'd; and so expos'd to the Sun, or open Air. The *Leaves* must be quite cover'd with Water, and as it evaporates a fresh Quantity must be pour'd in. In about a Month's Time, some of the *Leaves* will begin to putrify, but the others must be kept two Months longer. When the two external Membranes begin to separate, and the green Substance of the Leaf to grow liquid, then it is Time to perform the Operation. The *Leaf* is to be put into a white and flat earthen Plate or Dish, filled with clear Water; then upon gently squeezing it with the Finger, it will open on one Side, and the green Substance will run out; immediately on that the two outer Membranes must be stripp'd off, chiefly in the Middle, and along the Nerves, where they adhere closely. If there be once an Opening, they will go off very easily; the Skeleton that remains between, is afterwards washed in clean Water, and kept between the *Leaves* of a Book.

The Method of preparing Fruits, as *Apples*, *Plumbs*, *Cherries*, *Peaches*, and the like, is as follows:

The finest and largest *Pears*, that are soft and not stony, are fittest for this Purpose; first pare them nicely, without squeezing them, taking Care not to hurt the Stalk or Crown; then put them into a Pot of Rain or fresh spring Water, cover it and let them boil gently, till they become thoroughly soft; then take them out, and put them into a Basin of cold Water, then take out one of them, and holding it by the Stalk with one Hand, and with one Finger and the Thumb of the other Hand, rub the Pulp gently off, beginning near the Stalk, and rubbing equally towards the Apex; and you will easily see in the Water how the Pulp separates from the Fibres, which being tenderest near the Extremities, there the greatest Care must be

* *Phil. Trans.* No. 416.

228 *To preserve the Specimens of Plants.*

taken. No Instrument is of Use in this Operation, except last of all a Penknife, to separate the Pulp sticking to the Core. In order to see how the Operation advances, fling away the muddy Water from Time to Time, and pour on clean. All being separated, the Skeleton is to be preserved in Spirits of Wine, the same is to be observed with *Apples, Plumbs, Peaches*, and the like.

Carrots, and other Roots, that have woody Fibres, must be boiled without paring, till they grow soft, and the Pulp comes off; not only several Sorts of Roots, but likewise the Barks of several Trees, may be reduced into Skeletons, presenting rare and curious Views of Vegetables.

C H A P. XLII.

To preserve the Specimens of Plants.

PRepare two Iron Plates as large as the *Specimens* you intend to preserve, let them be pretty thick, and very smooth on one Side, with Holes for Screws at each Corner; then take your *Flowers, Leaves, &c.* when full ripe, and of their true Colour, spread them on a brown Paper, with the Leaves as distinct as you can; if the Flowers are large, more Paper must be laid under them; and if thick you may pare away half thereof, as also of the Stalk so as to lie flat; then put these between the Iron Plates, screw them fast, and set them in an Oven for two Hours; after which take out the Flowers, and with a Brush dipp'd in equal Quantities of *Aqua fortis*, and *Aqua vitæ*, or Brandy, pass over the *Leaves* and *Flowers*; then lay them to dry on fresh brown Paper, and take the Quantity of a Walnut of *Gum Dragon*, which in less than 24 Hours will be dissolved in a Pint of Water, and with a Brush rub the Back-sides of the *Leaves* and *Flowers* to make them stick; then lay them in your Paper-Book, and they will always look fresh. *

C H A P. XLIII.

Of Charcoal, or burnt Vegetables.

Charcoal, or a *Vegetable* burnt black, affords an Object no less pleasant than instructive; for if a small Piece of *Charcoal* be suddenly broke, it will appear to have a very smooth Surface, but if examined by the *Microscope*, Abundance of Pores are discoverable in many Kinds of Wood, ranged round the Pith both in a circular and a radiant Order; and most of these so exceeding small, and so close to each other, that but a very little Space is

* *Phil. Trans.* No. 227.

left between them to be filled with a solid Body. These Pores, or rather Tubes, are so extremely small, that in a Line of them $\frac{1}{8}$ th Part of an Inch long, Mr. *Hook* reckoned no less than 150, therefore in a Line an Inch long were no less than 2700 Pores, and in a circular Area, or of a Stick of an Inch Diameter, are contained 5,725,350 Pores or minute Tubes, * a Number that to some perhaps may seem incredible, were they not left to the Judgment of their own Eyes to the Truth thereof. In *Cocus*, *black* and *green Ebony*, *Lignum Vitæ*, &c. these Perforations are abundantly smaller than those of soft light Wood; so prodigiously curious are the Contrivances, Pipes or Sluices, thro' which the Juice of *Vegetables* are conveyed.

*To prepare or make Charcoal of any Kind of Wood,
in order to examine it with the Microscope.*

The Body to be charred or coaled may be put into a Crucible, a Piece of a Musket Barrel, a Pot, or any other Vessel that will endure to be made red-hot in the Fire without breaking; cover it over with Sand, so that no Part of it be exposed to the open Air. Then set it into a good Fire, and keep it there till the Sand has continued hot, for a Quarter, Half, an Hour, or two, more or less, according to the Nature and Bigness of the Body. Then take it out of the Fire, and let it lie till the Sand be very near cold. The Wood may be taken out of the Sand well charr'd, and clear'd of all its watery Parts.

C H A P. XLIV.

Of the Texture of Cork.

IF an exceeding thin Slice of *Cork* be cut off with a very sharp Penknife, or Razor, and applied to the *Microscope*, in an Ivory Slider, or held between the Nippers, it will appear to be all perforated and porous; having but a little solid Substance in Proportion to the empty Cavity, as is manifest on a Sight of Fig. 540. These Pores are not very deep, but consist of many little Cells, separated out of one continued long Pore, by certain Diaphragms, † visible in Fig. B, which represents them split the long ways: Hence the *Microscope* informs us, that the Lightness of *Cork* proceeds from its being a very small Quantity of a solid Body, extended into exceeding large Dimensions, and also why it is a Body so very unapt to suck in Water, and consequently to preserve itself floating on the Top thereof, tho' left on it never so long; and why it is able to confine Air in a Bottle, tho' confi-

* *Hook's Myc.* p. 101. † *Ibid.* p. 113.

derably condensed, and pressing very strongly to procure a Passage without admitting the least Bubble to pass through its Substance. As to the first, the Microscope hath informed us that the Substance of Cork is filled with Air, and that this Air is perfectly inclosed in little Boxes or Cells distinct from each other: This therefore makes it very plain, that neither Water nor any other Air can easily insinuate itself into them, their being already within them an *intus existens*; * for this Reason Pieces of Cork are good Floats for *Nets* and *Stopples* for *Vials*, &c. and is capable of being compressed into a twentieth Part of its usual Dimensions, and to restore itself to its former State by means of the included Air in the before-observed constituent *Cells* or *Bladders*. Mr. *Hook* told several Lines of these Pores, and found that there were generally about 60 placed Endwise in a Line of the $\frac{1}{15}$ Part of an Inch long: Whence there must be 1160 in the Length of an Inch, and in a square Inch 1166400; therefore a cubick Inch must contain 1259712000, a Thing almost incredible, did not the *Microscope* assure us of it by ocular Demonstration. If you cut off a Piece from a Board of Cork transversely to the Flat of it, you will as it were split the Pores, which will appear just as they are represented at Fig. B, but if a very thin Piece be cut off parallel to the Plane of it, the Pores of it will be transversely divided, and will appear as expressed in Fig. A.

C H A P. XLV.

S E C T. I.

Of a Plant growing on the blighted, or yellow Specks of Damask-rose Leaves, Bramble Leaves, &c.

IT is observable that in the Months of *June*, *July*, *August*, and *September*, that many of the green Leaves of *Roses* begin to dry and grow yellow, but especially the Leaves of the old Shrubs of *Damask Roses*, are all spotted with yellow Stains, and the Under-sides just against them have little yellow Hillocks of a gummy Substance, and several of them have small black Spots in the midst of those yellow ones. Upon examining these with the *Microscope*, Multitudes of little black Bodies like Seed-cods were perceived to spring out of several small yellow Knobs, and to be fastned to these Knobs by a small Straw-coloured and transparent Stem, many of those Hillocks were bare as if those Bodies lay yet concealed, as at G, Fig. 541. In others they were just springing out, as at A; in others, as at B, they were just out, with very little or no Stalk; in others, as at C, the Stalks

* *Hook. Mi. p. 113.*

Of a Plant growing on blighted Leaves. 231

plainly appear; in others, and at D, those Stems were grown bigger and larger; and in others, as E F, &c. those Stems and Cods were grown a great deal bigger, and the Stalks more bulky about the Root, and very much tapered towards the Top: As they increased in Bulk they began to turn their Tops towards their Roots, in the same Manner as that of Moss is observed to do. The whole Square of this Figure represents a small Part of a *Rose-Leaf* no bigger than the Letter H.

These kind of vegetable Sprouts are to be found on several Kinds of *Rose-Leaves*, and on the Leaves of divers Sorts of Briars, and on Bramble Leaves in such Clusters, that 3 or 400 of them make a conspicuous black Spot or Scab on the Backside of the *Leaf*.

S E C T. II.

Of Mouldiness, or the Principals of Vegetation arising from Putrifaction.

MR. *Leeuwenhoek* observed, that *Mouldiness* on Skin, Flesh, or other Things, shoots up first with a streight transparent Stalk, in which a globular Substancé rises that commonly settles at the Top of the Stalk, and is followed by another Globule driving out the first either on the Side or at the Top, and that again is succeeded by a third, &c. all which form on the Stalk one great Knob, much thicker than the Stalk itself; and this large Knob bursting asunder represents a kind of Blossoms with Leaves. *

The blue, white, and several Kinds of hairy mouldy Spots that are observable on divers Kinds of putrify'd Bodies, whether *animal* or *vegetable* Substances, such as the *Skin*, *raw* or *dress'd* *Flesh*, *Blood*, *Humours*, *Milk*, *Cheese*, &c. or rotten sappy *Wood*, *Herbs*, *Leaves*, *Barks*, *Roots*, &c. are a kind of small but variously figured *Mushrooms*; a Specimen of which is represented at Fig. 542. which is nothing else but the microscopick Appearance of a small white Spot of hairy Mould found upon the Covers of a Book that was bound in Sheep's Skin. These Spots appeared through the *Microscope* to be a very pretty shaped vegetative Body, which shot out Multitudes of long and slender cylindrical Stalks, not exactly streight, but bent with the Weight of a round white Knob growing upon the Top of each as at A A A; others a little oblong as at B, others a little broken as at C, and others that were burst asunder forming a kind of Blossoms with Leaves as at D.

* *Phi. Transf.* No. 94.

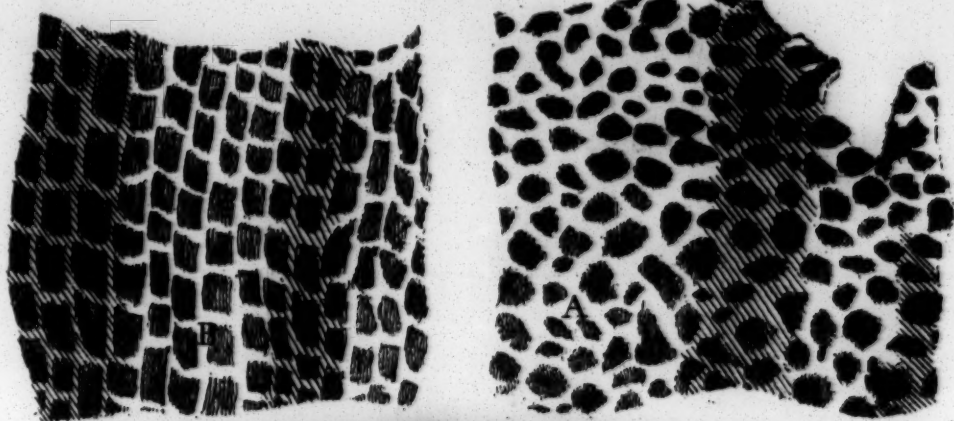
S E C T. III.

Of Moss, &c.

MOSS is a Plant no less worthy a microscopick Consideration than the most elegant Plant that grows, and for its Shape and Beauty may be compared with any other. It has a Root almost like a seedy *Parsnip*, Fig. 543. furnished with small Strings and Suckers, all of them being as curiously branched as the Roots of much bigger Vegetables; from this springs the Stem or Body of the Plant, which is finely creased or fluted; on the Sides of this are close and thickly set a Multitude of well shaped Leaves, some of them of a roundish, others of a longer Shape; all the Surface on each Side the Leaf is curiously cover'd with a Multitude of little oblong transparent Bodies, as at D, Fig. 546. From the Tops of the Leaves proceeds a transparent Hair or Thorn: The Stem shoots out into a long round Stalk, which on cutting is found to be hollow without any Knot or Stop, from its Bottom where the Leaves encompass it, to the Top on which grows a large Seed-Case A, covered with a thin and more whitish Skin B, Fig. 544. terminated in a long thorny Top, which at first covers all the Case, and by degrees, as that swells, the Skin cleaves, and at last falls off together with its thorny Top, leaving the Seed-Case to ripen, and scatter its Seed, at a Place underneath this Cap B, which before the Seed is ripe appears like a fluted Metal Button, without any Hole in the Middle; but, as it ripens, the Button grows bigger, and a Hole appears in the Middle of it E, Fig. 545. out of which, in all Probability, the Seed falls; for as it ripens by the Provision of Nature that End of this Case turns downwards. On opening several of these dry red Cases F, they were found to be quite hollow; whereas when they were cut asunder with a sharp Penknife when green, in the Middle of this great Case was found another small round Case, the Interstices between the two Cases being filled with Multitudes of stringy Fibres which seemed to suspend the lesser Case in the Middle of the other, in which without doubt the Seeds were contained; it grows on the rotten Parts of *Stone, Bricks, Wood, Bones, Leather, &c.*

This small Vegetable is wanting in nothing of the Perfections of the most conspicuous and vastest Vegetables of the World, and deserves to be ranged in as high a State; for we do not know but that all the Contrivances and Mechanism requisite to a perfect Vegetable, are crowded into exceedingly less Room than this of *Moss*; for that Plant already described, which grows on *Rose-Leaves*, is so exceeding small that near 1000 of them would hardly make the Bigness of one single Plant of *Moss*; and by comparing the Bulk of the latter to that of the biggest Vegetable (some Trees being, as we are informed, near 20 Foot in Diameter in *Guinea* and *Brazil*) whereas the

540



541



542





the Body or Stem of *Moss* is generally not above $\frac{1}{10}$ Part of an Inch, we shall find that the Bulk of one will exceed that of the other, no less than 2985,984,000,000; and supposing the Production of the Rose-Leaf to be a Plant, those *Indian* Plants will exceed it 1000 Times the former Number, so prodigiously various are the Works of the *Creator*, and so *all-sufficient* is he in his Performance of Things which to *Man* would seem impossible.

S E C T. IV.

Of Sponge.

THE *Microscope* hath shewn us, that *Sponge* is composed of an infinite Number of small and short Fibres, curiously joined together in the Form of a Net, as appears by Fig. 547. which represents a Piece of *Sponge* as it appeared before the *Microscope*, wherein may be seen the Joints which for the most part are, where only three Fibres meet together, the Length of each between the Joints is very irregular, the Distance between some two Joints being ten or twelve Times more than between others. The Mashers likewise of this reticulated Body are also various, some bilateral, others trilateral, and quadrilateral Figures, &c.

S E C T. V.

Of the Beard of a wild Oat.

THE Beard of a wild *Oat* is a Body of a very curious Structure; it grows out of the Side of the inner Husk that covers the Grain of a wild *Oat*. Its whole Length when extended does not exceed an Inch and a half. When the Grain is ripe and very dry, which is usually in the Months of *July* and *August*, the Beard is bent almost to a right Angle, and its under Part is wreathed and very brittle.

If you take one of these Grains and wet the Beard in Water, the small bended Top will presently turn and move round, and by degrees, if it be continued wet enough, the Joint or Knee will streighten itself, and if it be suffered to dry again, it will gradually bend into its former Posture. Its Appearance in the *Microscope* is represented by Fig. 548. which shews Part of the Beard at the Knee or Bend. Its whole Surface is adorned with little Channels and interjacent Ridges, which run the whole Length of the Beard, and are streight where the Beard is not twisted, and wreathed where it is, being thickly set with small Bristles; in the wreathed Part was two very conspicuous Channels which seemed to divide the wreathed Cylinder into two Parts, a bigger and a less, the biggest at the convex Side of the

H h

Knee;

Knee; these Clefts are filled with a kind of spongy Substance, very conspicuous near the Knee.

This odly constituted Vegetable is sometimes used, as an Hygrometer,* to discover the various Constitutions in the Moisture and Dryness of the Air; and this it does to Admiration.

C H A P. XLVI.

S E C T. I.

Of Salts.

UNDER the Denomination of *Salt*, is to be understood most of that which gives Solidity to Bodies, is dissolvable in Water, and affects the Taste with a peculiar Pungency. There are three distinct Sorts which generally pass under this Name, the *fixed*, *volatile*, and the *essential*: The fixed is what remains after Calcination, and is procured by dissolving the saline Parts of the Ashes in hot Water, and evaporating it until the Salt is left dry at the Bottom; for that will not rise in Vapours. The *volatile* is what easily passes over the Helm, as the Salts of Animals. The *essential Salt* is that which is obtained by Chrystilization from the Juices of Plants, and is of a Nature between the other two, and may most properly be termed essential, having no Force used in its Production.

If there be in a strict Sense any such Thing as a *Principal*, Salt is so; but then it must be termed *fossil Salt*, or *Sal Gemma*; for this not only appears to be the plain Production of Nature, but to be the most homogeneous and uncompounded Part Nature can be divided into.

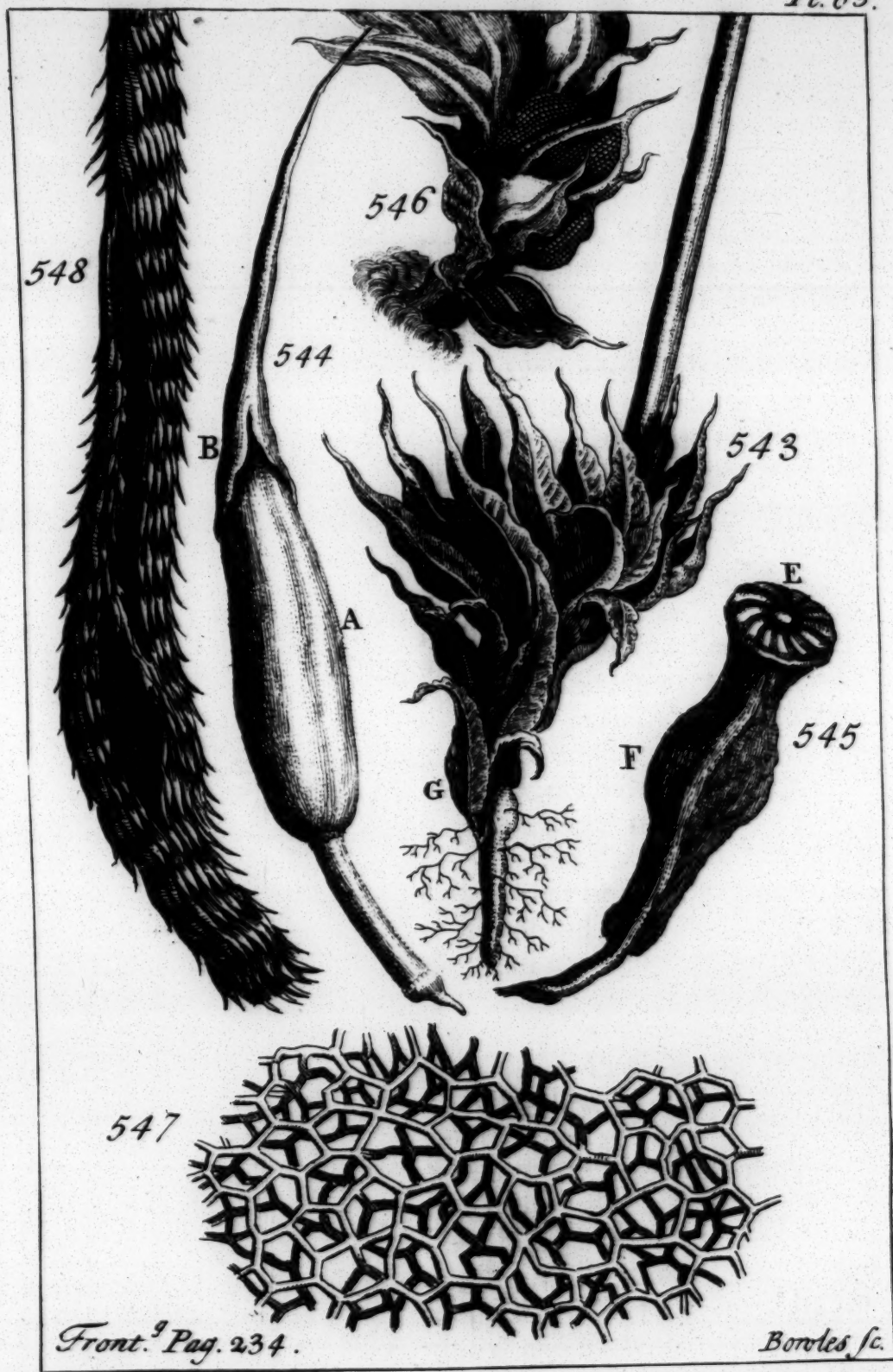
Its first Appearance is in Springs and Rivers, being washed into them by subterraneous Currents; thence by the Sun it is in some measure exhaled by Vapours; from whence it again returns, in *Snow*, *Hail*, and *Dews* (for common Rain-Water does not seem to partake of it;) from this Return the Surface of the Globe is saturated with it; whence it re-ascends in the Juices of Vegetables, and enters into all those Productions, as Food and Nourishment which the Creation supplies.

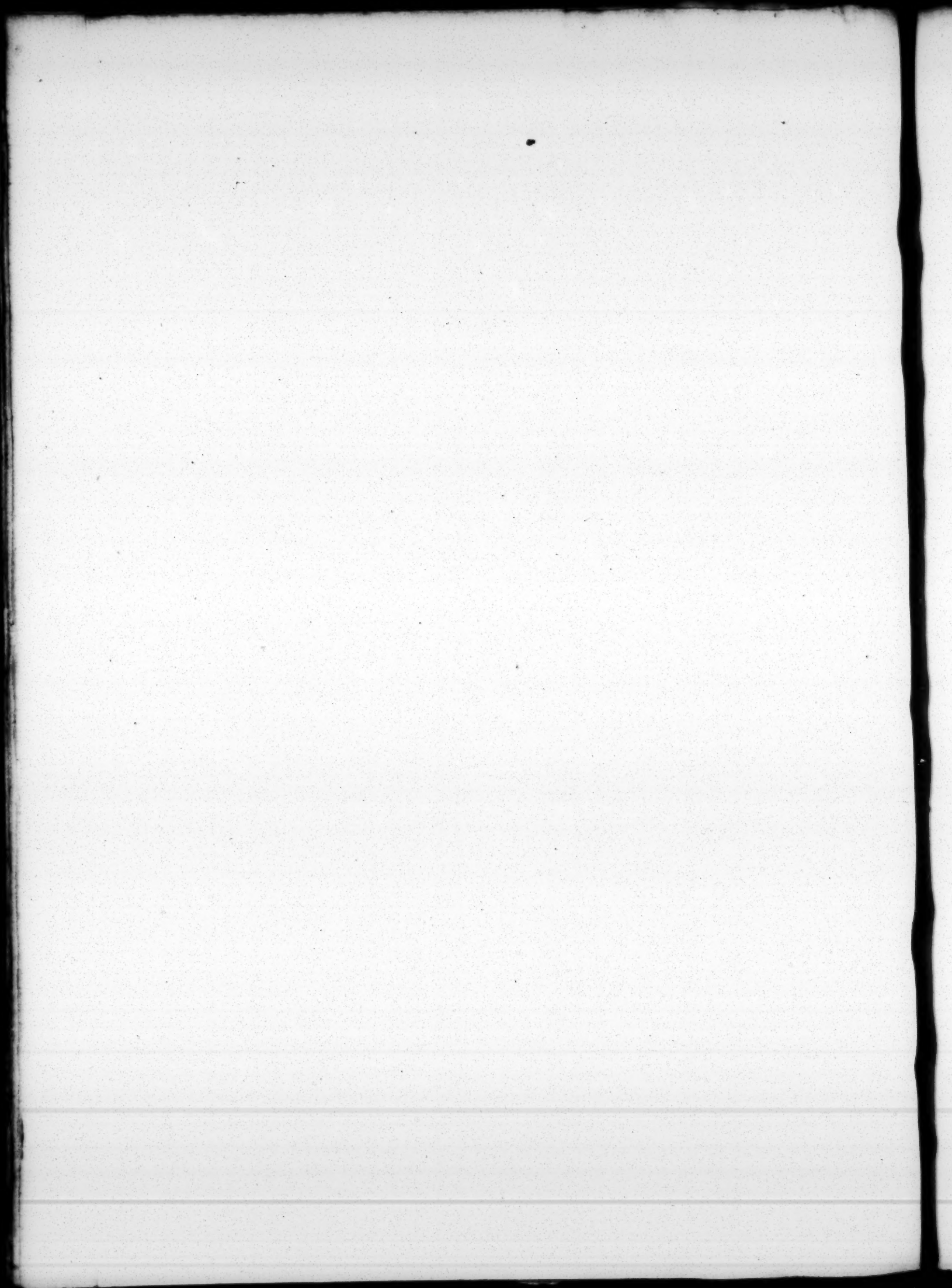
S E C T. II.

To extract vegetable Salts.

BURN any Sort of *Herb*, *Flower*, *Fruit*, *Wood*, or whatever it be, and make Ashes thereof; with the Ashes and pure Water in its natural Temper, make Lee; which afterwards strain through moist Paper or a

* If the Reader is desirous of one of these Hygrometers, he may be furnished with them at my Shop, &c.





Filter, so that it may become as clear as possible; then put the Lee into a Glass Vessel, and let it remain* in *Balneo Mariae*, until a great Part of it evaporates; the Quantity of Water is not determined, generally five Pounds of Water will extract all the Salt from two Pounds of Ashes; Salts extracted in this Manner, are wont to melt when the Air is soft; to prevent which, when you burn the Materials, in order to reduce them to Ashes, it is requisite to use with them a proper Quantity of Sulphur; and if it happens that the Ashes are made to your Hand, you may mix them with Sulphur, and keep the same at the Fire, till such Time as it be burnt; by this Means the Salt will never come to run, but become more white and crystalline. There is no general Rules for the Quantity of Sulphur to be put into the Materials you thus burn, but at a Guess, to 100 Pounds of Material, 4 or 5 Ounces of Sulphur is usually sufficient. All Salts have a peculiar and determined Figure, which they always keep, altho' they are often resolved into Water, and afterwards congealed; yet notwithstanding some Sorts of Salts are observed to have 2, 3, and 4 Sorts of Figures. Two Sorts have been seen in Lettice, in the *Scorzoneras*, in the *Musk-Melon*, the *Scopa*, in the Roots of *Efula*, in the *black Hellebore*, in *Endive*, *Eye-bright*, *Wormwood*, *Sorrel*, and in Shoots of *Vines*; three Sorts in *black Pepper*, and in incarnate *Roses*; four Sorts in white *Hellebore*. Besides the above-mentioned Diversity of Figures which are found in *Salts*, it is observable, that amongst all *Salts*, of what Figure soever, there are found some *cubical*, which though they be never so often dissolved and congealed, appear still of a cubical Figure, or inclining to it. To make the Bodies of the Salts when they congeal, remain distinct from each other, that their Figure may be observed, and not be entangled and heaped together; it is necessary, that very great Diligence be used in evaporating the Lee; for if that be wholly evaporated, or too great a Part thereof, the *Salts* make a confused Crust at the Bottom of the Vessel; if the Lees are left too weak, the Salts require a very long Time to congeal, and therefore it is requisite to use such Diligence as is not to be gained without long Practice.

Crystals of *Salts* are such a Combination of saline Particles, as resemble the Form of a Crystal, variously modified, according to the Nature and Texture of Salts.

The Method herein used is this, dissolve the *saline Body* in Water, after which filter the Solution, which being evaporated until a little Film appears upon it, runs into Crystal. Dissolution and Filtration are made Use of, that the Salts may be purged from all Dross; otherwise if any foreign Matter should get in, not only the Transparency of the Crystals would be impaired, but their Figure also would be mangled and broken.

S E C T. III.

Of the Figures of Salts.

IT is generally agreed, that all Bodies have their *Salts*, which produce many surprising Changes, by their different Configurations and Impressions, both in Solids and Fluids, in Things animate and inanimate. As to the Figures of them, they are obvious to every Beholder; their Beauty and Variety are so admirable, that scarce any Thing in Nature can entertain the Eye more agreeably than these do, when it is assisted with a good *Microscope*.

In common *Salt*, we plainly discover *quadrilateral Pyramids* with square Bases. In *Sugar*, the same *Pyramids* with oblong and rectangular Bases. In *Allum*, they rise with six Sides, supported with an hexagonal Base. The Crystals of *Vitriols*, resemble Icicles, united one to another with great Variety, among which lie some Polygons. *Sal-Armoniack* very elegantly imitates the Branches of a Tree; and *Hart's-Horn* looks like a Quiver of Arrows; *Glauber's Sal Mirabilis*, which is made of common *Salt* and *Vitriol*, exhibits the Figure of both Salts. *Nitre* appears in certain prismatick Columns, not much unlike Bundles of Sticks; among which there are interspers'd some of a Rhomboidal, and Pentagonal Figure, which seem to come very near those of common *Salt*. Hence *Lemery* very justly remarked, that *Nitre* could not be purified by any Art or Contrivance whatsoever, but something of a *Sal Gem*, or *fossil Salt*, would stick to it; but *Salt of Tin* out-does all for Beauty, in which are Lines like little Needles, that spread themselves every where from a Point, as from a Center, so as to represent a Star, much like what we see in the *Regulus of Mars*.

Salts have this peculiar Property, that let them be ever so divided and reduced into minute Particles, yet when they are formed into Crystals, they each of them re-assume their proper Shape; so that they may be as easily divested and deprived of their Saltiness, as of their Figure. Whence by knowing the Figure of the Crystals, we may understand what the Texture of the Particles ought to be, which can form these *Crystals*. And by knowing the Texture of the Particles, we may determine the Figures of the *Crystals*. For since the Figures of the most simple Parts remain always the same, 'tis evident the Figures which they run into, when compounded and united, must be uniform and constant.

Essential Salts are made by expressing the Juice of any Plant, and setting it in a Cellar to shoot; which some do in small Quantities.

Fixed

Fixed Salts are made as follows :

Take any Plant, and burn it on a clean Hearth, and rake the Ashes as long as any Fire appears among them ; put those Ashes into an unglazed Pan, which set in a calcining Furnace, make Fire about it till the Pan is red-hot ; where keep it, continually stirring the Ashes without any Blackness. Then put them into a clean Pan, and pour hot Water upon them ; when that Water is sufficiently impregnated with Salt, filter it, and evaporate to a Dryness, until the Ashes are left insipid.

The Salts of *Metals* or *Minerals* are to be come at, by quenching them, when red hot in Water, then filtering, evaporating, and crystallizing.

If *Allum* be burnt, dissolved in Water, and strained, its Crystals will consist of two sexangular Planes, whose Sides are bounded by six other, three of which are quadrilateral, having between them three of a sexangular Figure ; as at Fig. 548.

Green Vitriol affords Crystals, which are made up of ten unequal sided Planes, the Middle-most are Pentagons, and each of its sharp Ends triangular Planes ; as at Fig. 549.

The Crystals of our Inland *Salt Springs* are of a cubical Figure, as at Fig. 550.

Salt-Petre shoots into long Crystals, whose Sides are six Parallelograms ; as at Fig. 551.

It has been already mentioned, that Vinegar owes its Pungency to the Salts which float therein ; their Shape is seen at Fig. 552. Expose a Drop or two of Vinegar to the open Air for an Hour or two upon the Object-carrying Glass R, that its watery Parts may evaporate ; then apply it to the *Microscope*.

The *Salts* of *Sugar candy'd*, are represented at Fig. 553. The *Salts* of *Nitre* are seen at Fig. 554. The *Salts* of *Campfire*, at Fig. 555. *Sal Gem* is represented at Fig. 556. and *Sal Armoniack* at Fig. 557.

It is best to examine all *Salts* in the smallest Masses, for in them their Shape will be best discovered.

C H A P. XLVII.

S E C T. I.

On striking Fire with a Flint and Steel, &c.

ON striking Fire with a Flint against a Steel, little Particles of Steel are struck off, and melted into Globules by the Collision ; which will be evident on spreading a Sheet of white Paper, and observing the Place where several of these little Sparks seem to vanish. Mr. *Hook* examined several of them with a *Microscope*, and found that a black Particle, no bigger

238 *On striking Fire with a Flint and Steel.*

ger than a Pin's Point, appear'd like a Ball of polish'd Steel, as at Fig. 558. and strongly reflected the Image of the Window, and of a Stick which he moved up and down between the Light and it. Others were, as to their Bulk, pretty round, but their Surface not so smooth; some were cracked, as Fig. 559. others broke in two, and hollow, as Fig. 561. several others were found of other Shapes; but that represented at Fig. 560. was observed to be a big Spark of Fire, and stuck to the Flint, by the Root F, at the End of which Stem was fastened an Hemisphere, or hollow Ball. It is also remarkable, that some of these Sparks are Slivers, or Chips of Iron vitrified, others are only the Slivers melted into Balls, without Vitrification, * and the third Kind are only small Slivers of the Iron, made red-hot with the Violence of the Stroke given on the Steel by the Flint.

Many Sorts of Sand, some gather'd on the Sea-shore, or on the Sides of Rivers, and some found on the Land, differ in the Size, Form, and Colour of their Grains, some being transparent, others opake, some have rough, and others quite smooth Surfaces. It would be endless to describe all the Figures to be met with in these Kind of minute Bodies, they being spherical, oval, pyramidal, conical, prismatical, &c. Mr. Hook trying several magnifying Glasses, by viewing a Parcel of white Sand, casually hit upon one of the Grains, which was exactly shaped and wreathed like a Shell, which he separated from the rest of the Granules, and found it to appear to the naked Eye no bigger than a Pin's Point, but when viewed in the *Microscope*, it appear'd as in Fig. 562. resembling the Shell of a small Water Snail; † it had twelve Wreathings, growing all proportionably one less than the other, towards the Middle or Center of the Shell, where there was a very small round white Spot. In this minute Shell we have a very good Instance of the Curiosity of Nature, in another Kind of Animals, removed by their Smallness beyond the Reach of the naked Eye; and as there are several Sorts of Insects and Vegetables, so small as to have had no Names; so likewise by this, we find there are also exceeding small, or rather minute Shell-fish. Nature, by the Assistance of the Microscope, having shewn to us her Curiosities, in every Tribe of *Animals*, *Vegetables*, and *Minerals*.

S E C T. II.

Of small Diamonds or Sparks in Flint.

A *Flint Stone* being broke in Pieces, the inside Cavity of it appear'd to be crufted all over with a pretty candid Substance, reflecting the Light from some of its Parts very vividly; but on examining it with the *Microscope*, the whole Surface of that Cavity could be perceived to be beset with

* *Hook's Micr.* p. 44.

† *Ibid.* p. 80.

a Multitude of little crystalline or adamantine Bodies, curiously shaped, as at B, Fig. 563. and afforded a very agreeable Object.

An Atom, or Globule of *Quicksilver*, when placed before the Microscope, seems like a convex Mirrour, in which may be seen all the circumambient Bodies; as the Windows, Trees, and Furniture, &c.

S E C T. III.

Of Mercurial Powders, &c.

I N those chymical Preparations of Mercury, which is called *Turbith Mineral*, *Mercurius Vitæ*, *Dulcis*, *Sublimate*, *Precipitate*, and *Mercury Cosmetical*, *Calomel*, and all other mercurial Powders, are found, when examined by the *Microscope*, to be full of minute Globules of crude and unalter'd Mercury; which shews, that those chymical Preparations are not so purely exalted and prepared as they are presumed to be, nor the Mercury any Way transmuted, but by an atomical Division rendered insensible.

C H A P. XLVIII.

The Nature of Snow, &c.

M ANY of the Parts of *Snow*, are for the most Part of a regular Figure, and as it were so many Rowels or Stars with six Points, and are as perfect and transparent *Ice** as any we see on a Pool of Water; at each of these six Points are set other collateral Points, and these always at the same Angles with the principal Points themselves; that amongst these, many others alike regular, but far smaller, may be discover'd; there are also some others, which seem to have lost their Regularity, by various Winds, being first gently thawed, and then frozen again into irregular Masses; from all which, *Snow* seems to be an infinite Number of *Icicles*, regularly figured, not only in some few Parts thereof, but originally in the whole Body of it; not so much as one Particle of so many Millions being originally indeterminate or irregular; that is, a Cloud of Vapours being gather'd into Drops, do forthwith descend; in which Descent, meeting with a freezing Wind, or at least passing through a colder Region of the Air, each Drop is immediately frozen into an *Icicle*, shooting itself into Points or *Icicles* on all Sides from the Center; but still continuing their Descent, and meeting with warmer Air, some are thawed and blunted, others broken, but the greatest Number cling together in several Parcels, and form what we call *Flakes of Snow*; hence we understand why Snow, tho' it seems to be soft, is really hard, be-

* *Philos. Transf.* No. 92.

cause it is a real *Ice*, whose inseparable Property is to be hard, its Softness being only apparent. The first Touch of the Finger upon any of its sharp Edges or Points instantly thaws them, otherwise they would pierce the Fingers like so many Lancets; and hence also why *Snow*, tho' a real *Ice*, and so dense and hard a Body is notwithstanding very light, which is the extream Thinness of each Icicle in respect of its Breadth: Hence it also appears, why *Snow* is white, because it consists of Parts, each of which singly is transparent, but mixed together, appear white, as the Parts of Froth, Glass, Ice, and other transparent Bodies, whether soft or hard.

A B C D E F, Fig. 564. represents a few of an infinite Variety of curious Figures that are to be observed in *Snow*.

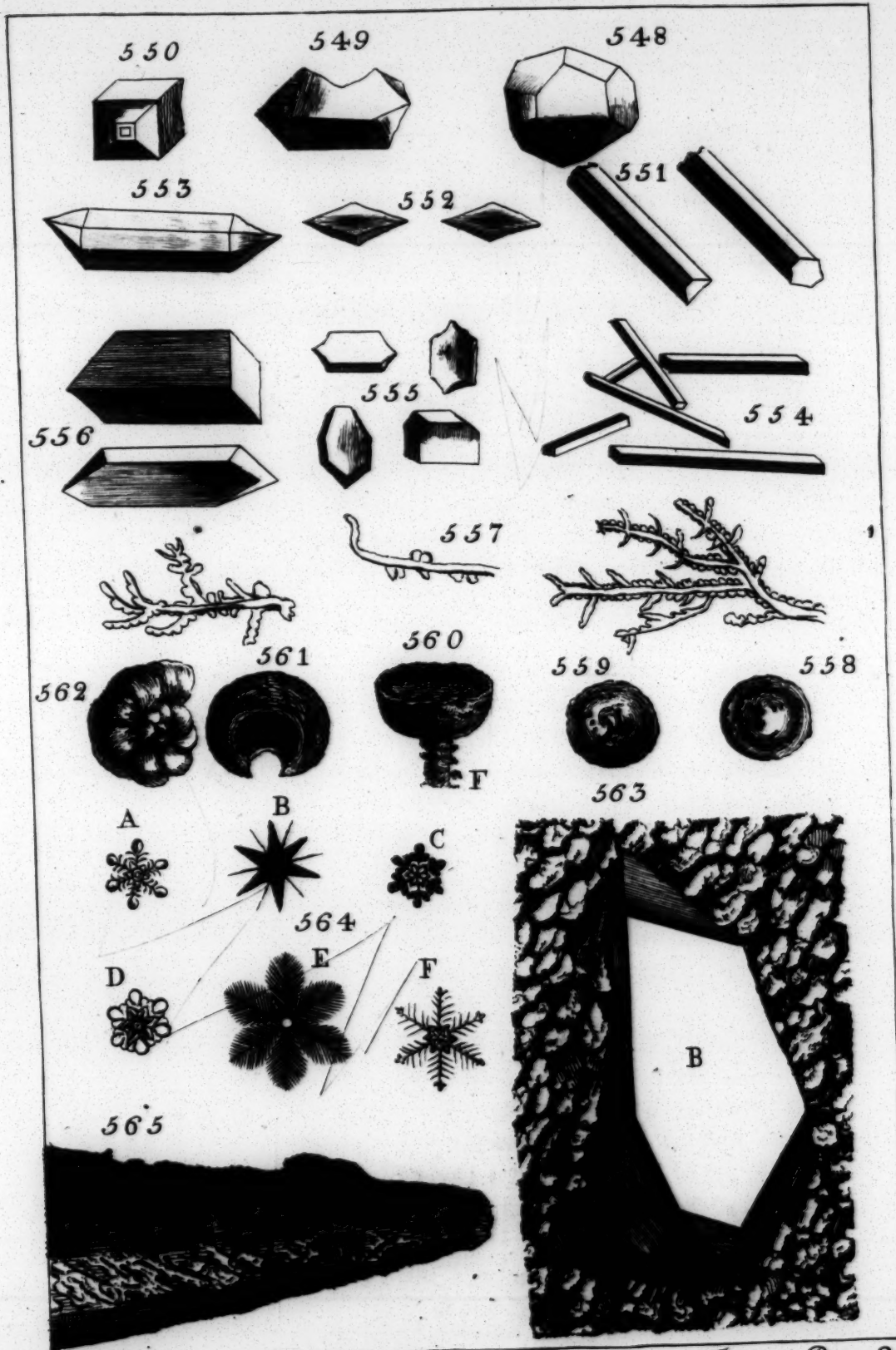
In which it was observable, that if they were of any regular Figures, they were always branched out with six principal Branches, of equal Length and Shape. As these Stems were for the most Part of the same Make in one Flake, so were they in differently figured Flakes, very different; but this was constantly observed, that of whatever Figure one of the Branches were of, the rest were exactly the same.

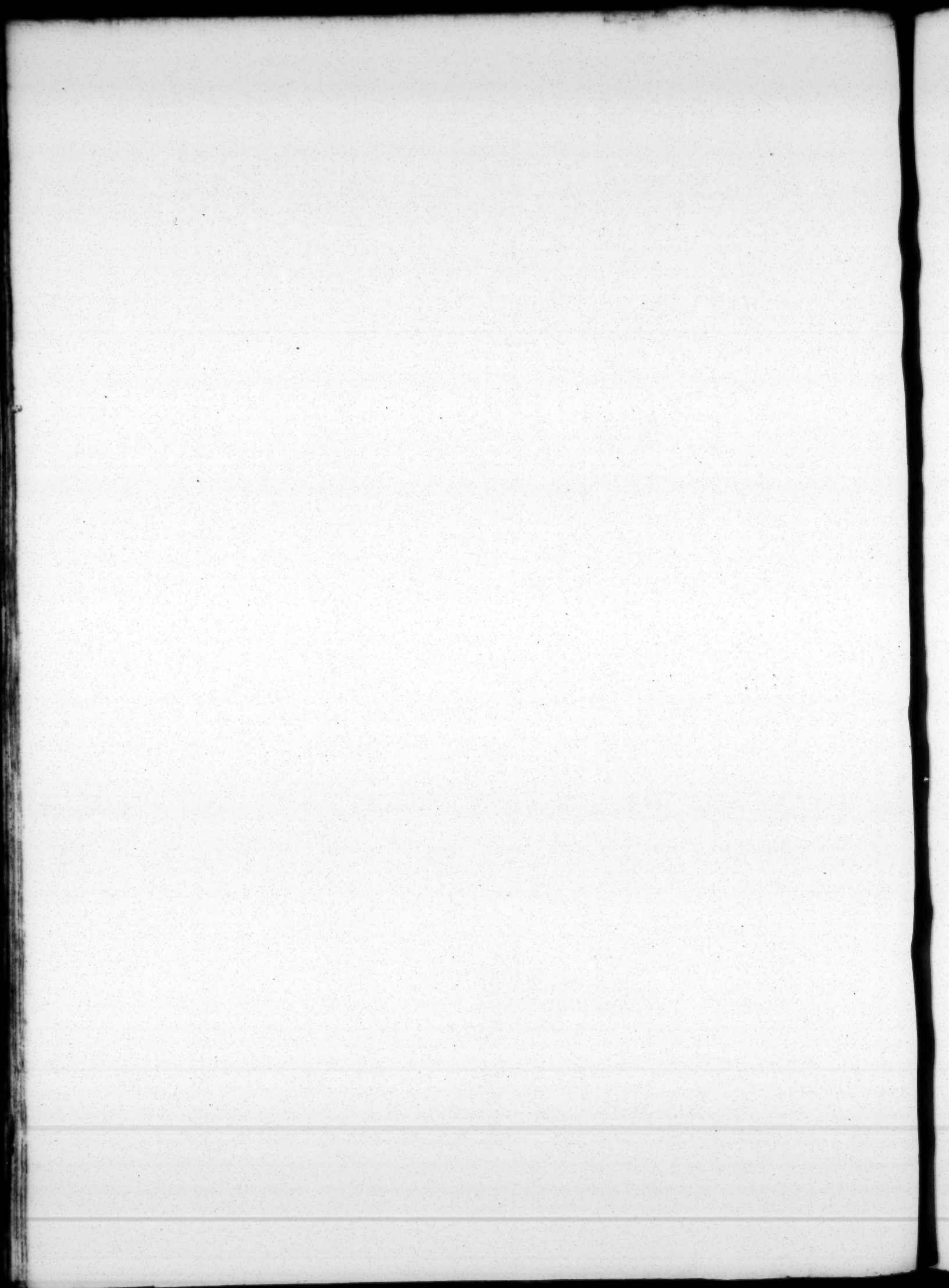
The Point of an exceeding small Needle, appeared, when greatly magnified like Fig. 565. neither round nor flat, but very irregular, and tho' to the naked Eye it was very smooth and sharp, yet upon this Examination, it appear'd to be full of Holes * and Scratches; so unaccurate is human Art in all its Productions, even in these which seem to be the most neat, that if examined with an Organ more accurate than that by which they were made, the more we see of their Shape, the less Appearance will there be of their Beauty; whereas in the Works of Nature, the deepest Discoveries shew us the greatest Excellencies; for in the Sting of a Gnat, or a Bee, the Proboscis of a Butterfly, or Flea, they appear, when examined by the Microscope, to be formed with the most surprising Beauty, exquisite Workmanship, and an exact Regularity of, and Likeness in Parts is preserved in each Particular of every Species; an evident Argument, that he who was, and is the Author of all these Things, is no other than OMNIPOTENT; being able to include as great a Variety of Parts and Contrivances in the most minute Point, as in the largest Body.

Fig. 566. represents a very small Dot, Tittle, or Point, that is generally the Mark of a full Stop or Period. Amongst Multitudes that were observed by the *Microscope*, few could be found so round and even as this here delineated, † but when greatly magnified, it appear'd to be rough, jagged, and uneven all about its Edges, and very far from being truly round, as at Fig. 567. the most curious and smoothly engraved Strokes and Points, when examined by the Microscope, look but like so many Furrows and Holes; and their printed Impressions, but like smutty Daubings on a Mat,

* *Hook's Micr. p. 2.*

† *Ibid. p. 2.*





or uneven Floor, made with a blunt extinguished Brand. Several Pieces of small Writing, reckoned very curious of their Kind, one of which in the Breadth of a Silver Two-pence, compriz'd the *Lord's Prayer*, the *Apostles Creed*, the *Ten Commandments*, and about six Verses besides out of the *Bible*, being examined by the *Microscope*, shew'd what the Writer had asserted was true, but withal discovered it to be compos'd of as shapeless, barbarous, and uncouth Letters, as if written in *Arabian* and *Chinese* Characters.

A Part of the *Edge* of a very keen *Razor* was so placed between the *Microscope*, and the *Light*, that there appear'd a Reflection from the very Edges, and was perceived to be sharper in some Places than in others, indented at others, broader and thicker at others, and unequal and rugged; that Part of the *Edge* which is polished by the *Hone*, appear'd to be prodigiously full of Scratches, crossing each other every Way; besides it had several deep Furrows. That Part of the *Razor* which was polished upon the *Wheel*, look'd almost as rough as a plow'd Field. *

Mr. *Leeuwenhoek* caus'd himself to be shaved with the sharpest *Razor* he could pick out of five by the Help of a magnifying *Glass*. At first it was very soft and easy, but at last it grew so painful he could not endure it, and upon viewing it with his *Microscope*, he found in it many more Notches than at first. In another he found little Holes in six several Places near the *Edge*. He wash'd the Back of his Hand with plain Water, and then with this same *Razor* scrap'd off the little Hairs, and on observing the *Razor* again, found that those little Holes were turn'd into Notches, and that several Pieces of the *Razor* were broken out. From whence it appears, that if the *Razor* be too soft, it yields to the Hairs, if too hard, the Hair causes several Notches in it. In short when we observe thro' a *Microscope* the several Notches there are in the finest *Razor*, it is surprizing how any of them can cut so well. †

Fig. 568. represents a Piece of exceeding fine *Lawn*, as it appear'd thro' the *Microscope*, which from the great Distances between its Threads, appears like a Lattice, and the Threads themselves seem coarser than Rope-Yarn.

Fig. 569. exhibits a microscopick Appearance of a very fine Piece of Ribband, being not much unlike that Substance of which *Door-Mats* are made. If the *Silk* be white, each Thread appears like a Bundle or Wreath of transparent Cylinders; if colour'd, they appear curiously ting'd, each of which affording in some Part or other a vivid Reflection, in so much, that the Reflection of Red appear'd as if coming from so many Garnets or Rubies.

Hence it is evident, that there are but few artificial Things worth observing with a *Microscope*, for which Reason I shall conclude here; the

* *Hook's Micr.* p. 4.

† *Phil. Transf.* No. 273.
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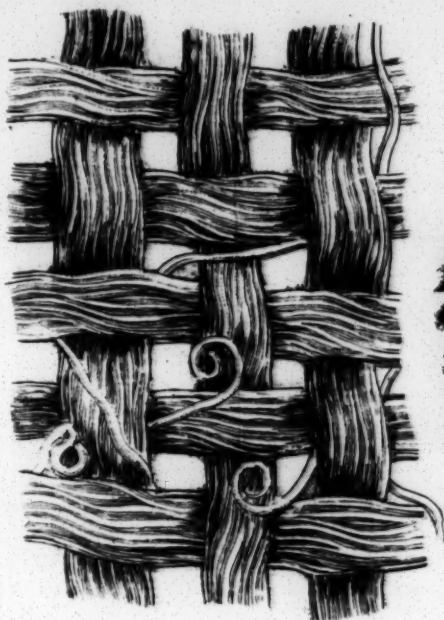
Productions of *Art* being such rude mishapen Things, that when viewed with that Instrument, we can observe very little in them but their Deformity. The most curious Carvings, appear no better than those rude *Russian* Images mentioned by *Purchas*; where three Notches at the End of a Stick stood for a Face: And the most smooth and polished Surfaces that we can possibly meet with, appear rough and uneven. Therefore why should we endeavour to find Beauties in Things which were designed for no higher a Use than to be viewed by our naked Eye? But only that we may see the *Defects* of human Art, when compared to those of *Nature*, in whose Forms there are something so surprizingly small and curious, and their design'd Business so far removed beyond the Reach of our natural Sight, that the more we magnify those minute Objects, the more Excellencies and Mysteries appear; and the more we are enabled to discover the Weakness of our own Senses, as well as the Omnipotency and infinite Perfections of the *Great CREATOR*.

F I N I S.



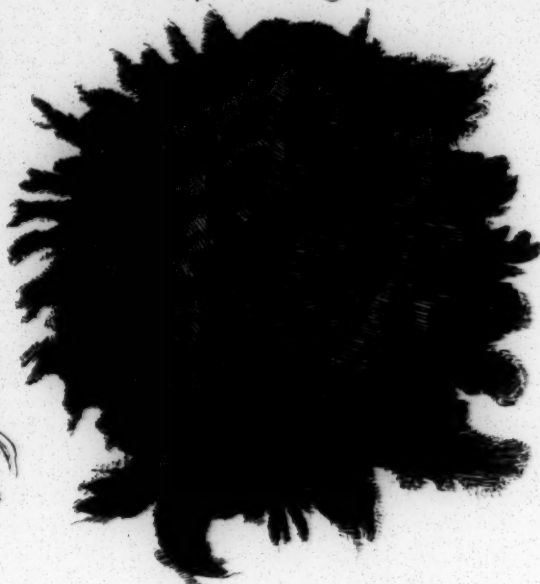
A C A T A-

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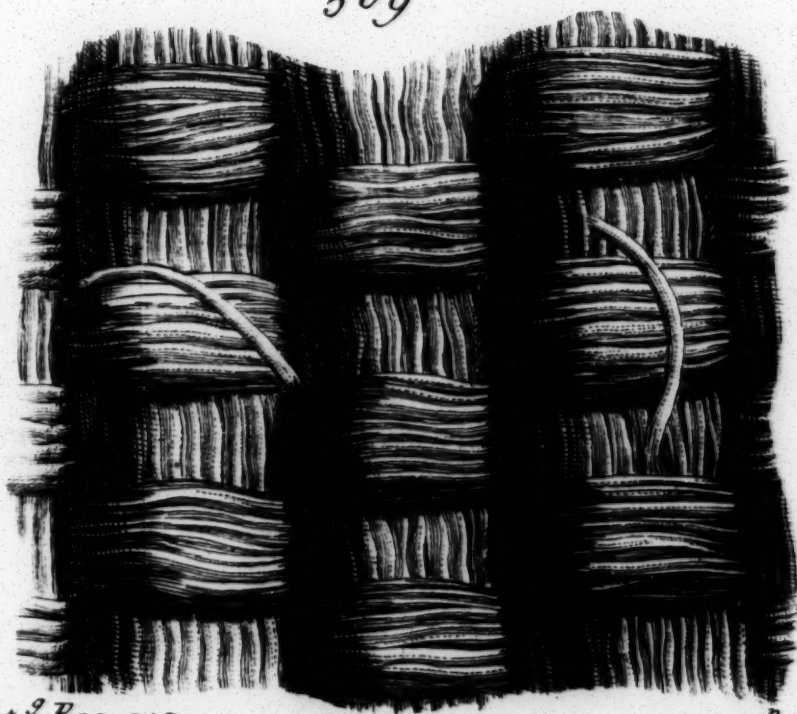


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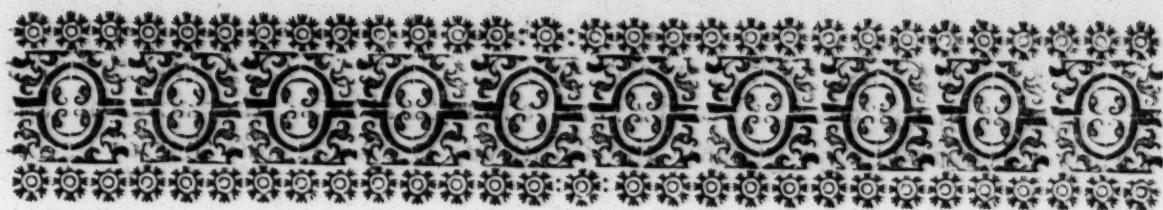
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Front. 9 Pag. 242.

Bowles jr.





A
C A T A L O G U E
O F

Mathematical, Philosophical, and Optical
I N S T R U M E N T S,

As Made and Sold by

G E O R G E A D A M S,

At Tycho Brahe's Head, in Fleet-Street, London.

THE Study of the Mathematicks is now so generally esteemed, as to become a necessary Part of almost every Gentleman's Education. Nor need we wonder at the great Progress, which this Science has, of late Years, made in most Parts of *Europe*; since it contains such an inexhaustible Fund of useful Knowledge, as is sufficient to gratify almost every Taste, and employ every Talent. The noblest Genius may, in the Pursuit of it, exert his utmost Faculties; and the meanest will not fail of finding something that is within his Reach. The Theory affords an ample Field to the speculative Part of Mankind, and the Practice is productive of several Advantages to Men of Action and Business.

In order, therefore, to render this Treatise, in some Measure, of general Use, I have subjoined an extensive CATALOGUE, of the greatest Part of *Mathematical, Philosophical, and Optical* Instruments, that are now in Use among the most judicious and learned Men throughout *Europe*.

Mathematical Instruments are the Means by which those noble Sciences, Geometry and Philosophy, are render'd useful in the Affairs of Life. By their Assistance an abstracted and unprofitable Speculation, is made beneficial in a thousand Instances: In a Word, they enable us to *connect Theory with Practice*, and so turn what was only bare Contemplation, into the most substantial Uses.

The Knowledge of these leads to that of *practical* MATHEMATICKS, and *experimental* PHILOSOPHY; so that the Uses of mathematical and philosophical Instruments, make perhaps one of the most *serviceable Branches* of Learning in the whole World; and the natural Way, therefore, of rendering this Knowledge general and diffusive, is by making that of its *Instruments* so.

As *practical* Mathematicks, and *experimental* Philosophy, teach us the *Powers* of Nature, the *Properties* of natural Bodies, and their mutual Actions on one another: This Knowledge cannot be attained without *Instruments*, and the Conclusions and Proofs we expect from it, depend very much upon their *Exactness*. In order therefore to give a sufficient Satisfaction to those Gentlemen who have honour'd me with their Custom, it hath always been my particular and greatest Aim to produce such *Instruments* as might facilitate the *Progress* of *Mathematical* and *Philosophical Learning*, which *Motive* hath been, and still is as pressing with me as that of *Interest*. For,

In the Construction of all the Machines I have ever made, my first and greatest Care hath been to procure good *Models* and *Drawings*, several of them I have imitated from the *best Authors*, as well *Foreigners*, as those of *our own Country*; I have alter'd and improved others, and have added many new ones of my *own Invention*. And,

1. In all my Performances I endeavour not to *augment* the Instruments and Machines with *superfluous Ornaments*, both that they may be of *frequent Use* to those of *middling Fortunes*, and that their *Neatness* may render them not unworthy of a Place in the Cabinets of the Curious.

2. That their *Exactness* may be particularly attended to, I always inspect and direct the several Pieces myself, see them all combined in my own House, and finish the most *curious Parts* thereof with my own Hands.

3. To the End that their *Construction* may be as *simple* and *substantial* as the *Uses* of the Instruments will *admit*; it is my constant Study to contrive them in such a Manner that they may be managed with the *greatest Ease*.

4. I also have Respect to their being made applicable to *several Operations*, especially when the *Extent* of their *Use* does not *prejudice* their *Simplicity*, to the End that Instruments may not be multiplied without Necessity.

In the following CATALOGUE I have ranged the Instruments in *Classes* under the Heads of their several *Branches*, and have *number'd* each particular *Instrument*, so that if a Gentleman is desirous of any one or more of them, and is at any Distance from LONDON, he need only send me the Numbers adjoining to those he intends to purchase, and he shall be served with Fidelity, and at the lowest Prices.

Instruments for Geometry, Drawing, &c.

Variety of Pocket Cases of *Drawing Instruments*, in Silver, Brass, &c.
Containing,

- 1 *Plain Compasses* for measuring Lines, &c.
- 2 *Drawing Compasses*, with three moveable Points, viz. an Ink Point for sweeping Circles, or Arches of any determinate Thickness, a dotting Point, and a black Lead Point.
- 3 A *Drawing Pen*, either with or without a protracting Pin.
- 4 A *Sector* for finding Proportions between Quantities of the same Kind, as between Lines and Lines, Surfaces and Surfaces, &c. either of Box, Ivory, Brass, Silver, &c.
- 5 *Plain Scales*, or,
- 6 A *square Protractor*, or,
- 7 *Parallel Ruler*, which is also a Protractor, &c. } either of Box, Ivory, Brass, Silver, &c.
- 8 A *Semicircle Protractor* of Brass.

In the best Cases, the Compasses are always made with Steel Joints, and the Knibs of all the Pens are made to turn up, or open with a Joint, in order to clean them, in which are also sometimes put,

- 9 A Pair of *Hair Compasses*, so contrived on the Inside of one of the Legs, that an Extent may be taken to an Hair's Breadth.
- 10 A Pair of *circular Compasses*, with which a Circle as small as a Pin's Head may be described.

In a *Magazine Case* of *Drawing Instruments*, is generally contain'd all the above Instruments, together with the following Particulars.

- 11 A Pair of *Drawing Compasses*, with moveable Legs longer than those of No. 2.
- 12 A Pair of *strong Compasses*, with Calliper and cutting Points.
- 13 A Pair of *Beam Compasses*, for drawing larger Circles, and taking larger Extents.
- 14 A Pair of *Proportionable Compasses*, for the ready diminishing Plans or Drawings, in any assigned Proportion.
- 15 A 12 Inch *Brass Sector*, of a peculiar Make.
- 16 A Pair of *Triangular* } *Compasses* for transferring three or four Points
- 17 A Pair of *Quadrangular* } at once, from a Map or any Drawing to another to be copied.
- 18 A Pair of *Compasses*, with two Pair of Points, whose shorter Legs are at all Openings always half the Distance of the longer ones.
- 19 A Pair of *Plat Compasses* for measuring Charts.

- 20 A *tracing Point* having at its upper End an oval Plate for clearing the Drawing Pen of any Dirt or Grit that may happen between the Knibs, and in the Middle thereof is a protracting Pin.
- 21 *Elliptical Compasses* for drawing Ellipsis or Ovals of various Sizes.
- 22 A *Bow* for drawing curved Lines.
- 23 A *Porté crayon*.
- 24 A large *Plain Scale*,
- 25 A *Plotting Scale*,
- 26 A *Protractor*,
- } Sometimes these are all made in one Instrument.
- 27 *Plain and Parallel Rulers*, of several Sizes.
- 28 Bottles and Shells of Water Colours.
- 29 *Ivory Pallates* for *Indian Ink* and Colours.
- 30 A *Pointrel* and *Feeder*.
- 31 A Pair of *Gunners Callipers*.
- 32 A *Recipient Angle* for measuring the external and internal Angles of Fortifications, Buildings, &c.
- 33 *Dialling Scales*, &c.
- In these Magazine Cases, Gentlemen may have what Number of Instruments they think proper.
- 34 The *Solids* in *Euclid's Elements* cut in Wood, with all their proper Sections, design'd on Purpose for the Ease of those Persons, who would inform themselves demonstratively in the Practice of *Perspective*, *Mensuration*, *Sphericks*, &c.
- 35 The five *regular Solids*, or *Platonick Bodies* cut in Wood.
- 36 A *Cylinder* bisected.
- 37 A *Cone* with all its proper Sections.

Rules of all Sorts,

For Measuring of Timber, Stone, Painting, Brick-work, Plaistering, Glazing, Gauging, &c. Viz.

- 38 *Carpenters Rules*.
- 39 *Folding Rules*.
- 40 *Coggeshall's Sliding Rules* for measuring Timber.
- 41 *Scammozzi's Rules*.
- 42 *Everard's Sliding Rule* for Gauging.
- 43 *Leadbeater's Sliding Rule*.
- 44 *Veroy's Sliding Rule*.
- 45 *Brenan's Rule*.
- 46 *Malt Canes*.
- 47 *Dimension Canes*.

- 48 *Four-Foot Gauging Rule* with Joints.
- 49 *Five Foot Ditto.*
- 50 *Tape Boxes.*
- 51 *Five Foot Rods*, for measuring Brick-work, Wainscotting, Painting, &c.
- 52 ————— *Ditto*, in Canes.
- 53 *Horse Measures* in Sticks and Canes, &c.

Surveying Instruments.

- 54 *PLAIN Tables*, with an Index and Sights, whereby the Draught or Plan is taken on the Spot, without any future Protraction, having a Compass fitted to one of its Sides, and the whole fixed upon a Ball Socket, with a three legg'd Staff, upon which it may be turn'd round, or fasten'd with a Screw, as Occasion requires.
- 55 *Plain Tables improv'd*, with an Index of a peculiar Make, whereby the Line of Sights in viewing, is always over the Center of the Table, which also is readily set over the Station Hole, the Station Lines are likewise drawn parallel to those measured on the Land; and the Table is set horizontal by a Spirit Level, &c.

Plain Tables are very useful in taking the Ground Plot of Buildings, and measuring Gardens, or small Enclosures (where the Shortness of Lines, and Multiplicity of Angles are apt to breed Confusion in protracting) but by no Means fit for surveying large Tracts of Land, because the least Moisture, or Dampness in the Air, makes the Paper not only sink, but run up when dried again; and thereby the Lines drawn thereon, make the Content less than it should be; and in the least Rain or Mist the Instrument is not at all to be used, which Reasons has induced most Persons to use fitter Instruments for large Tracts of Ground. As the
- 56 *Theodolite*, for measuring Angles, Distances, Altitudes, &c. Those Instruments are made various Ways, some being more simple and portable, others more accurate and expeditious.
- 57 *The Plain Theodolite*, which consists of four plain Sights, two fasten'd to the Limb, and two on the Ends of the Index, with a Compass on the Index Plate, divided into Degrees, and the Limb subdivided into Minutes by a Nonius Division, the whole fitted on a Ball and Socket, and that placed upon a three-legg'd Staff.
- 58 *Theodolites*, with all the above Particulars, and the Addition of a Telescope.
- 59 *Theodolites of the latest Improvement*, being the most accurate Instrument yet invented for surveying Land, which by a peculiar Contrivance

trivance in the Head of the Staff, may be set truly horizontal. On the Index, and over the Compass-Box is fixed a double Sextant, to move exactly in a vertical Circle, within which is a Spirit Level, and over that a Telescope, so contrived, that when the Bubble rests in the Middle of the Spirit Tube, the Interfection of the Hairs in the Telescope will cut an exact Level, the double Sextant is divided in such a Manner as to shew on one Side thereof the Degrees and Minutes of any Altitude or Depression within the Extent of its Divisions. On the other Side are Divisions for taking the Height of Timber standing in Feet; and on the Limb there are also Divisions for measuring its Breadth. It must be also observed here, that both horizontal and vertical Angles are observed at the same Time, which is extremely useful in laying down Plots, when the hypothenusal are to be reduced to horizontal Lines; when the Telescope is directed to any Object, the whole Instrument is fixed in so firm a Manner, that on directing the Telescope to the next, the Limb remains entirely stedfast, which in other Instruments of this Sort, is very difficult to be effected.

- 60 *Circumferentors*, the principal surveying Instrument used in the *West Indies*. It is very simple, yet expeditious in the Practice, and consists only in a Brass Circle, with a Compass divided into 360 Degrees, on the Center of which is suspended a magnetical Needle, and an Index, on whose Extremities are two Sights; the whole is mounted on a Staff, and sometimes for Conveniency of its Motion, on a Ball and Socket.
- 61 *Gunters*, or four Pole *Chains*.
- 62 *Offset Staves*.
- 63 Sets of *Arrows* for the Chain.
- 64 *Air Levels* which shew the Line of Level, by Means of a Bubble of Air and Spirits of Wine hermetically inclosed within a Glass Tube, which is mounted in a Brass Tube, on a particular Frame, and may be included in a Case for the Pocket.
- 65 *Air Levels*, with Sights, which consist of an Air Level set in a Brass Tube, with an Aperture in the Middle, being fixed on a straight Ruler on whose Ends are Sights for taking the Level of any Place.
- 66 *Air Levels*, with Telescope Sights, are somewhat like the former, but with this Difference, that instead of plain Sights it carries a Telescope to determine the Point of Level precisely, at a good Distance, these Levels are mounted on a three-legg'd Staff, and have a particular Contrivance; by which they may be adjusted (if put out of Order) to a true Level at any one Station.
- 67 *Artillery Levels*.
- 68 *Gunners Levels*.

- 69 *Levelling Staves.*
- 70 *Plotting Scales.*
- 71 *Sets of feather-edg'd Scales.*
- 72 *Hair Scales.*
- 73 *Parallel Rulers* for Plotting.
- 74 *An improv'd Protractor*, and Plotting Scale, in Form of a Beam-Compass.
- 75 *Parallelograms*, for the ready and exact Reduction, or copying of Designs, Schemes, Prints, &c. which is done hereby without any Knowledge or Habit of Designing.
- 76 *Pedometers*, somewhat like a Watch, by which the Way may be measured in Walking.
- 77 *Measuring Wheels* for Surveying of Land.
- 78 *Way-Wisers*, for Coaches.
- 79 *Way-Wisers* of a curious and particular Contrivance for Chaises, &c.
- 80 *Gunners Quadrants*, Heights, &c.
- 81 *Surveying Quadrants*, made of Brasses, or Wood, &c.

Navigation Instruments.

- 82 *Gunter's Scales.*
- 83 *Sliding Gunter's.*
- 84 *Davies Quadrants.*
- 85 *Mr. Hadley's reflecting Quadrants.*
- 86 *Mr. Smith's reflecting Quadrants.*
- 87 *Mr. Smith's, Capt. Middleton's, and Capt. Harrison's improv'd Azimuth Compasses.*
- 88 *The common Azimuth Compasses.*
- 89 *Azimuth Compasses, on Friction Wheels.*
- 90 *An artificial Horizon* of a new and curious Contrivance.
- 91 *Mariner's Compasses*, either for the Binnacle or Cabin.
- 92 *Nocturnals*, adapted to the Polar Star, and the first of the Guards of the little *Bear*; and also to the Polar Star, and the Pointers of the great *Bear*.
- 93 *Nocturnals*, which are a Projection of the Sphere, such as Planispheres, Hemispheres, &c.
- 94 *Rectifiers* for determining the Variation of the Compasses, in order to rectify the Ship's Course.
- 95 *Plane Scales.*
- 96 *An Instrument* for taking the Latitude of a Place at any Time of the Day. May be easily understood, it immediately shews the Latitude

tude of the Place, and gives the Time of the Day at *Sea*, when no other Instrument will.

- 97 A *Machine* to measure the *Strength* of the *Wind*.
- 98 A *Machine* to sound the *Depth* of the *Sea* without a *Line*.
- 99 A Contrivance to fetch up Water from any Depth of the *Sea*.
- 100 *Marine Barometers*, for foretelling Storms at *Sea*.
- 101 *Sinical Quadrants*.
- 102 *Telescopes*, *Prospects*, and *Spy-Glasses*.
- 103 *Navigation Books*, *Charts*, &c.

*Instruments for shewing the Motion, Attraction,
Weight, and Equilibrio of Bodies, &c.*

- 104 A *Machine* and *Glass-Planes* for the Drop of Oil of Oranges.
- 105 Two *Planes* in a Frame to be set in a Vessel of tingid Liquor.
- 106 *Capillary Tubes* and Apparatus.
- 107 A *Column* with sliding Arms, additional Pieces, Nuts, Screws, Hooks, Pullies, &c. of a very useful, curious, and particular Contrivance, adapted to support a great Number of the Apparatus, in which Pullies, Leavers, Ballances, Weights, Pendulums, &c. are used both in Mechanicks and Hydrostaticks.
- 108 A *strong Ballance* graduated, for explaining the Properties of Leavers, in which the *Power*, *Resistance*, and Point of Suspension are moveable; and may be readily placed in any given Proportions.
- 109 A *Prism* with a *Steel Edge*.
- 110 *Awls* in Brass Handles to illustrate the Center of Gravity.
- 111 An Instrument and Apparatus for 3 *Leavers*.
- 112 Compound *Leavers*.
- 113 An *Axis* in *Peritrochio*.
- 114 A *double Cone*, that runs up an inclin'd Plane, which is two Rulers, so dispos'd as to be inclined to each other, and to the Horizon, which double Inclination may be varied as the Experiment requires.
- 115 A *Cylinder* that runs up an inclined Plane.
The two last Machines prove, that a Body cannot remain at rest, when its Center of Gravity is not lowermost.
- 116 A *Machine* to demonstrate the Properties of an inclined Plane, so contrived, that its Inclination may be changed from an horizontal Plane to that of a vertical one, and the acting Power may be placed in any given Direction.
- 117 A little Carriage, and its Appendages, for shewing the Advantage
great

great Wheels have over little ones, and that in all Sorts of Roads, as Clay, Gravel, Sand, Pavements, &c.

118 Machines for oblique Forces.

119 *Blocks*, or *Sheaves of Pullies*, after all the various Sorts of Combinations and Constructions, curiously framed, and turned in Brass, and running either on Steel Arbors, or Pivots, in which all possible Care is taken to diminish their Friction.

120 A Machine to explain the Nature and Properties of the *Wedge*. In which the Wedge is formed of two jointed Rulers, that may be set to any Inclination from each other, by which Means the Base of the Wedge is varied, as may also its Force and Resistance, by a new and curious Contrivance.

121 A Collection of several Wheels and Pinions, to shew that either of these act as *Pullies*, and their Proportions as *Leavers*.

122 A Model of *Archimedes's Screw*, the Effect of which becomes sensible, by the rising of several little Balls therein.

123 A Machine for explaining the Nature of the *Watch-Spring* and *Fussey*.

124 An Instrument to explain the Effects of *Friction* in Machines.

125 A Machine for shewing the Acceleration of *falling Bodies*.

126 A *strong Ballance*, and its Appendages for the same Uses.

These two last Machines do not only shew that Bodies are accelerated by falling, but also makes the Laws of this Acceleration evident.

127 An Instrument to illustrate *Motion* and *Velocity*.

128 A double Pendulum, mounted on a Trough, divided into two equal Parts by a Partition, for shewing the Proportions of *resisting* Mediums.

129 An Instrument for comparing the Swiftness of a Body falling in a *Cycloid*, with that of another Body, down an inclined Plane.

130 Another Instrument for comparing the Descent of two Bodies, from any Part of an inverted *Cycloid*.

131 A Machine to shew the Direction of a Body that is impressed with a perpendicular and horizontal Motion.

132 Another Machine, by which is also shewn a Motion produced from two Directions.

133 A Machine for shewing the Line that a Body describes in falling, after having received an horizontal Direction.

134 A Machine for shewing the Motion of a Body, neglecting its proper Weight, after having received by falling, a Direction oblique to the Horizon.

As the Curve in Question depends upon the Obliquity of its Direction, the Instrument is constructed in such a Manner, that the Degrees of its Obliquity may be varied.

135 A Machine for explaining the Theory of *central Forces*; contrived in such a Manner, that its Friction makes no sensible Error: The

Celerity and Bulk of the Bodies may be varied at Pleasure. Their Times are shewn by Sound, and the Spaces run through by an Index.

- 136 A *Glass Globe* fixed to a double Axis, which may be whirl'd with any Degree of Velocity, both in a vertical and horizontal Direction.

With this Machine the Effects of central Forces may be seen on Fluids of different specifick Gravities, when mixed together, or on Solids which float therein.

- 137 A *flexible Globe*, or *Sphere*, whose Poles are capable of being depressed, on its being turned, by which Means the centrifugal Force raises the Equator, and represents the Form of an oblate Spheroid to the Eye, which is the Figure attributed to the Earth from the late Discoveries.

- 138 A Machine for the *Congress* of *Bodies*, both elastick and non-elastick. Its Parts are adapted in the most convenient Manner, to facilitate a Contact which does not change the Direction of the Bodies, whose Solidities or Masses are in known Proportions; the Points of Suspension are advantageously disposed, and their Effect made sensible by an Index.

- 139 A *Cronometer*, or Instrument to measure small Spaces of Time.

- 140 A *Machine* and Table for *compound Motion*, in which the Hammers are suspended in such a Manner, as to regulate the Quantity of Motion, either by their Celerity or Weight.

- 141 A graduated *Arch*, and *swinging Scale*, for shewing that a Body thrown up perpendicular from any other Body in Motion, will fall exactly on the same Place, notwithstanding both the Bodies are moved.

- 142 An Apparatus to strain Wires or Strings a-cross a Room for Experiments of the like Nature.

- 143 An Instrument to explain the Force of *Springs*, &c.

- 145 Models {
 of a Press.
 of a Capstan.
 of Cranes of various Sorts.
 of Mr. *Allen's* Crane at *Bath*.
 of an Engine to drive Piles, &c.
 of an Engine to saw off the Tops of Piles under Water.

Many other Models of Machines, which are principally designed to explain the Application of simple Machines, in those which are combined, in all which Care is taken to leave those Places expos'd, where the chief Motions are to be observed.

- 146 An Instrument to explain the Laws of *Elasticity*, on Springs and Wires, &c.

- 147 *Large Weights*, for several Experiments.
- 148 *Smaller Weights*, of a peculiar Shape, from half an Ounce to Six Pounds.
- 149 A *moveable Table* for various Experiments, that may be rais'd or lower'd.
- 150 A Pair of *Scales* for various Experiments.

Instruments for Experiments on the Motion, Weight, and Equilibrio of Fluids.

- 151 **A** *Trough* lin'd with Lead, and furnished with a Cock; for several Hydrostatical Experiments.
- 152 A *Glass Phial*, with a solid Stopper, which in this State is heavier than a like Bulk of Water.
- 153 Several Tubes bent in different Forms.
- 154 An Apparatus for proving how Fluids press against the Bottom and Sides of their containing Vessels, being composed of several Vessels, which may be successively placed upon one common Base; the Piston, which is the Bottom hereof, is so adjusted, as to cause no sensible Error by its Friction, the Columns of the Fluid remain always at the same Height, and the Weights act in a uniform Manner.
- 155 *Hydrostatical Bellows*.
- 156 A Glass Tube with a Bladder fixed at one End.
- 157 A Glass Bucket and wooden Cylinder.
- 158 An *Hydrostatical Ballance* of a commodious Structure.
- 159 An hollow Glass Ball with a Cock to it, to prove that Water weighs in Water.
- 160 *Areometers*, or Liquor Proofs, of Glass.
- 161 *Hydrometers* of Brass or Copper.
- 162 A Glass Vessel for changing Water into Wine, and *vice versa*.
- 163 A Brass cylindrical Vessel, with a Solid of the same Size, to shew that Bodies plunged in Fluids become lighter.
- 164 A Glass Vessel to be suspended to the Arm of a Ballance, for Experiments of the same Kind.
- 165 Two Balls of the same Weight, but of different specifick Gravity, to be hung to the Arm of a Ballance, for shewing, that what Bodies lose of their Weight, on being plunged into Water, is in Proportion to their Bulk.
- 166 A Machine for shewing that a Body emerged in a Fluid, changes its relative Weight, when the Bulk of the Fluid in which it is, is either condensed or rarified.

- 167 A *Syphon*, open at Top, to which may be fixed an exhausting Syringe, mounted on a Frame with a graduated Scale, for comparing the Densities of two Fluids at the same Time.
- 168 A cylindrical Glass Vessel, and hollow Images.
- 169 Two cylindrical Glass Vessels, mounted in a Frame, in which the hollow Glass Images may be moved by Compression, without being perceived by the Spectators.
- 170 A Model of the *diving Bell* and Apparatus.
- 171 A common Syphon, and others of different Forms.
- 172 A double Syphon.
- 173 A Syphon, whose Arms are moveable by Means of a Knee-like Joint.
- 174 A *Tantalus Cup* of several Fashions.
- 175 Glass Models of *Sucking* } *Pumps*, (with or without Air-Vessels)
 Forcing } which shew the Reasons of Fire-Engines,
 and *Lifting* } playing with a continual Stream.
- 176 A Fountain of *Command*.
- 177 ————— *Hiero.*
- 178 ————— *Double.*
- 179 A *large Fountain by compressed Air*, with Variety of Jet d'Eaux, to which also may be applied an Apparatus for shewing the various Curves that are made by Projectiles.
- 180 A *Ballance to weigh Levity*.
- 181 An Apparatus to make Lead swim.
- 182 An Apparatus to make Cork sink.
- 183 A Column and *Reservoir* for *spouting Water*, with Tubes that may be inclined to any Angle Jet d'Eaux's, &c.
- 184 Two tall cylindrical narrow Jars, and several solid Cylinders of different Woods, to shew that they will sink differently according to their specifick Gravities.
- 185 A Glass-Bottle full of Holes.
- 186 Glass Bubbles, which, on being immersed in Water, become specifically heavier, lighter, and of the same specifick Gravity of the Water successively.
- 187 A Machine for shewing that Bodies emerged in Fluids, change their relative Weight, and will sink or rise therein, as the Fluid in which they are become more dense or rarified.
- This may be called an hydrostatical Thermometer.
- 188 Two Glass Bubbles, one swimming at the Top, and the other lying at the Bottom of the Water in a Glass Jar, so contrived, that by pouring in more Water, the Bubbles shall change Place.
- 189 A Machine for *spouting Mercury*, which shews the various Parabola's that are made by Projectiles, and particularly the Truth of the several

veral Rules in the Art of Gunnery, being constructed in such a curious Manner, that the Force may be varied as Occasion requires.

- 190 A peculiar Sort of Syphon, the Orifices of its two Legs being in the same Line, and yet the Water will run out, and tho' the Orifices be but in Part immersed, yet the Water will rise. This Machine produces its Effects tho' continuing dry for a long Time, that either of the Apertures being open'd, and the other remaining shut for Hours, or a whole Day, and then opened, the Water will flow out, and will rise and fall indifferently in either Leg.

N. B. All the Models of Pumps, Fountains, Syphons, &c. are made of Glas, in which all the Parts of Action may be easily seen.

Instruments for Pneumatical Experiments.

- 191 A Small single Barrel *Air-Pump*.
 192 A large double Barrel standing, or tall *Air Pump* and *Apparatus*.
 193 A double Barrel *Table Air-Pump*, which is the most useful of any, with a large Apparatus.
 194 A Machine particularly applicable to the double Barrel *Table Air-Pump*, for whirling Bodies in Vacuo, of a new Contrivance, by which all the electrical Experiments on whirling Globes, either exhausted of their Air, or not, may be repeated.
 195 An Apparatus for the Experiments of Fire in Vacuo.
 196 An Apparatus for the Experiments on Electricity in Vacuo.
 197 A Sortment of necessary Things for Experiments on Electricity in Vacuo.
 198 A very tall Receiver composed of several Pieces, with a curious Machine at Top, by which Experiments on falling Bodies may be five Times repeated in Vacuum, when the Air is only once exhausted.
 199 A double Transferer for communicating a Vacuum from one Receiver to another.
 200 Two Bras Hemispheres, with a Stop-Cock and Rings.
 201 A Bottle with a Jet d'Eaux, and a long Tube with a Receiver, for shewing that a small Quantity of included Air, presses equally with the whole correspondent Column of the Atmosphere.
 202 A Glas with a wooden Vessel at its Top, to prove the Porosity of Vegetables.
 203 A proper Vessel for proving the Skins of Animals are porous, and that an abortive Skin is not so.

- 204 A Machine to shew that dense Air will drive a yielding Solid into a Space occupied by rarer Air.
- 205 A Machine to strike two Hammers against a Bell in Vacuo, and compressed Air.
- 206 A Machine of a new Contrivance for making Experiments in compressed Air, and Apparatus thereto belonging.
- 207 An injecting Syringe.
- 208 A Wind-Gun, with a condensing Syringe in its Stock, having a Magazine of six Balls, from which one Ball at a Time may be put into the Barrel, without letting the Air escape, and once charging it with Air is sufficient for the Discharge of all the Balls.
- 209 Capillary Tubes of various Sizes.
- 210 An Apparatus for the *Mercurial Phosphori*.
- 211 An *Eolipile*.
- 212 An *Eolipile* on a Carriage.
A solid Globe to be heated, and a Frame to receive the same.
- 213 } *Thermometers*, for { of Spirits of Wine.
214 } measuring the In- { by Sir *Isaac Newton*'s.
215 } crease, and Decrease { by *Farenheit*'s, } Standard, { Spirits,
216 } of the Heat and { by *Reaumer*'s. } either of { Oyl,
217 } Cold of the Air, { by *D'Lisle*'s, &c. } { or
218 *Monf. Azont*'s Apparatus, for determining that it is the Air's Pressure which raises the Mercury in the Barometer.
- 219 Diagonal }
220 Stagnant }
221 Portable } *Barometers*.
222 Marine }
223 *Dr. Moreland*'s Statical }
224 *Mr. Caswell*'s Baroscope. }
- 225 An Apparatus for an *artificial Storm*.
- 226 An Apparatus for the Explosion of Gun-powder in Vacuo.
- 227 A *Pyrometer* of a new and curious Contrivance, for measuring the Expansion of Metals.

Optical Instruments.

- 228 *Spectacles* ground on Brass Tools, set in Silver, Tortoiseshell, Horn, &c.
- 229 *Reading-Glasses*, set in Variety of curious Frames.
- 230 *Concaves* for Myopes, or short-sighted Persons.
- 231 *Prospect-Glasses* of all Lengths.
- 232 *Opera Glasses*.
- 233 *Diagonal Prospects*.

- 234 *Telescopes* of all Lengths.
- 235 *Newtonian reflecting Telescopes* } The Speculums of which are finished
 236 *Gregorian reflecting Telescopes* } with the greatest Care.
- 237 *Microscopes, Wilson's*
- 238 ———— *Opake*
- 239 ———— *Double*
- 240 ———— *Adams's new invented Universal One.* And,
 241 ———— *solar Apparatus to do.*
- 242 *Camera obscura* of various Sorts.
- 243 *Camera obscura*, of a peculiar Contrivance, by which the Images of external Objects, are exhibited distinctly on a Sheet of Paper, each cloathed in their native Colours, perfectly like their Objects; and at the same Time all their Motions are expressed, which last no other Art can imitate. By Means of this Instrument, a Person unacquainted with Drawing, will be able to delineate Objects, to the last Accuracy and Justice; and another well vers'd in Painting, will find many Things herein to perfect his Art.

Instruments for Experiments on Lights and Colours.

- 244 **A** *N Helioſtata*, or Machine for directing the Sun's Rays into a dark Chamber, which of itself directs the Mirrour in a proper Manner, to cast the Rays in the same Line for several Hours together.
- 245 **A** Machine for shewing Experiments on the Attraction and Repulsion of the Rays of Light. Several Machines for Experiments on the Laws of the Refractions of the Rays of Light, viz.
- 246 Boxes with Glas Sides.
- 247 **A** wooden Box with sliding Sides, and changeable Ends.
- 248 Boxes, with Segments of Spheres, fixed in their Sides.
- 249 **A** solid Glas Cube.
- 250 **A** particular Stand to manage these Boxes upon, by which they may be rais'd, depressed, or turn'd round at Pleasure.
- 251 **An** artificial Eye, furnished with Lens's of different Foci or Ages, to shew the Reasons how Glasses help decayed Sights and Myopes.
- 252 **A** Semicircle and *Prism*, with Glas Sides to determine the Angles of Refraction.
- 253 **Three** *Prismatick* Boxes.
- 254 **Solid** Glas *Prisms*, mounted on Feet, by which Means they may be raised, depressed, inclined, or turned upon their Axis.
- 255 **Other** *Prisms*, mounted on a vertical Foot, which may be raised, or depressed, and turned upon their Axis.

- 256 *Prisms* of solid Glass not mounted.
- 257 A Plane *metalline Speculum*, mounted on a Foot that may be rais'd, depressed, inclined, or turned round at Pleasure.
- 258 A plain Glass *Mirroure*, mounted in the same Manner.
- 259 Several Glass *Lens's*, mounted in Frames, on Feet.
- 260 An Instrument to open a Passage for the Sun's Rays, with Holes of different Sizes.
- 261 A large double *Convex Lens* composed of two Segments, and mounted on a Foot for Experiments, on the Refraction of different coloured Liquors.
- 262 A large Paper *Screen* for Experiments on the Prisms, and the Solar Microscope.
- 263 *Concave* } Mirroures of all Sizes.
- 264 *Convex* }
- 265 { *Cylinders,*
- 266 *Metalline* { *Cones,*
- 267 { *Pyramids,* } with deformed Pictures.
- 268 { *Octagons,*
- 269 Pictures for a *pyramidical* Glass.
- 270 *Magick* Lanthorns.
- 271 Pictures to Ditto.
- 272 Hollow *Prisms* that may be exhausted.
- 273 An Instrument to determine the Refraction of Fluids.

Instruments, &c. for Experiments on Electricity, &c.

- 274 **N**atural armed *Load-Stones*.
- 275 *Artificial Loadstones*.
- 276 A Box of Filings, and Bits of Iron Wires, little Iron Balls, and Cylinders.
- 277 A Trough with enamelled Swans and Frogs.
- 278 An Iron Rod.
- 279 A polished Iron Blade.
- 280 A Compass Dial.
- 281 A long Needle in an oblong Box.
- 282 A Sea-Compass.
- 283 Several Steel Needles touched on the Load-stone.
- 284 A large Glass Tube, open at both Ends.
- 285 Another that may be exhausted.
- 286 A Glass Globe for whirling.
- 287 Another that may be exhausted and applied to the whirling Machine.
- 288 Glass Plates.

- 289 Several little Stands.
- 290 A solid Stick of Sealing-Wax, of a proper Length and Diameter.
- 291 A Tube of Ditto.
- 292 A Stick of Brimstone.
- 293 A Cone of Ditto, cover'd with a Glafs.
- 294 A little Amber Ball, and another of Coral.
- 295 Several little Ivory Cups.
- 296 A Metal Pyramid for the Communication of Electricity.
- 297 A Suspensor furnished with Ribbands of different Colours.
- 298 A Rosin Cake.
- 299 A Cake of Rosin and Gum Lac.
- 300 A Suspensor furnished with Silk Lines for communicating Electricity to living Bodies.
- 301 A very long Packthread String, with Balls for communicating Electricity a great Way.
- 302 Silken Lines for the same Purpose.

All the Apparatus necessary to perform electrical Experiments, as well in the open Air, as in Vacuum, are, if desired, carefully disposed in one Box to make them portable.

Instruments for Astronomy, Geography, &c.

- 303 **G***Lobes, celestial and terrestrial, of all Sizes, neatly fitted up, viz. of 3, 9, 12, 17, and 28 Inches Diameter, from the latest Observations.*
- 304 *Globes, fitted up in such a Manner, that the Poles of the diurnal Motion in a celestial Globe, pass in a Circle round the Poles of the Ecliptick, and serve the Purposes of Chronology and History for Times past, and will also answer the same Things for any succeeding Times to come; by which Means a View of the Heaven is obtained suitable to every Period, and will answer the antient Descriptions, as Eudoxus, who is supposed to have borrowed his from the most early Observations, and of Hipparchus, &c. Nor can any Contrivance better enable the meanest Reader to judge of the Merits of the Controversy about the Argonautick Expedition, as far as it depends on this, for it will verify to the Sight, the Place of the Colures, &c. at any Time. By this Contrivance the celestial Globe may be so adjusted, as to exhibit not only the Risings and Settings of the Stars in all Ages, and Latitudes, but the other Phænomena, likewise, that depend upon the Motion of the diurnal Axis round the annual ones.*
- 305 *Armillary Spheres of any Size.*

- 306 *Large Astronomical Quadrants*, fitted with a Telescope for taking the Declination of the Sun, Moon, and Stars, in the Meridian.
- 307 *Transit Instruments*, for determining their right Ascensions.
- 308 *Portable Astronomical Quadrants*, that have both a true horizontal and vertical Motion, for observing the Altitudes of the Sun or Stars in any Position, with which (having a good portable Pendulum) the Meridian and Latitude of the Place will be readily determined; which may be of great Use on the Sea-Coast, and in the Surveys of Countries.
- 309 *Equal Altitude Instruments* for observing Stars of equal Heights, with which having a good portable Pendulum, the Meridian and Latitude of a Place may be very accurately found.
- 310 *Telescopes*, fitted with a *Micrometer* for observing the apparent Magnitudes of the Sun, Moon, and Planets, with the Apulses of the Moon and Planets to the fixed Stars.
- 311 Mr. Gray's Instrument for drawing a Meridian Line and Telescope for observing the Time of the Night by the Pole Star.
- 312 *Helioscopes*, or Instruments for observing the Spots in the Sun.
- 313 *Parrallactick Telescopes*.
- 314 An *Astronomical Sector*, which is a very commodious and accurate Instrument, for taking such Differences of right Ascension and Declination, as are too large to be observed thro' a fixed Telescope, being very useful for observing the Places of the Planets or Comets when they are near any known Star.
- 315 *Meridian Telescopes* for correcting the Motion of a Clock or Watch, and finding the ascensional Differences of any Objects in the Heavens, by taking the Times of their Transits over the cross Hairs. The Differences of Declination of two such Objects as will pass over the Apertures of the Telescope, may be also found.
- 316 *Large double Instruments*, containing two chief Parts connected together, having four several Motions, all moved by Rack Work.
1. A circular Motion to shew all horizontal Angles.
 2. A Semicircular vertical Motion.
 3. A circular equinoctial Motion, or for any Place at right Angles to the Vertical.
 4. A Motion thro' a double Sextant, at right Angles to the Third, that has a refracting Telescope fixed to it. By this Instrument, all Angles, either horizontal, or of Elevation or Depression, the Azimuth and Altitude of any Star, the Meridian and Latitude of the Place, with the Hour of the Day and Night, are directly given; also the right Ascension and Declination of the Moon, a Planet, Comet, or any Star, at one Observation; which, if a Comet of quick Motion should appear, may be repeated every five or six Minutes, and thereby its Path well known.

- 317 A new *Universal Sun Dial*, having all the abovesaid four Motions but performed in a different Manner, with a particular and curious Contrivance for finding the Time of the Day, within a few Seconds of Time.
- 318 *Horizontal Sun Dials* of all Sizes and Sorts, for Pedestals in Gardens, or elsewhere.
- 319 *Portable Sun Dials* of various Kinds.
- 320 *Gnomonick Polyhedrons*, with several Faces, whereon various Kinds of *Dials* are projected; of this Sort, that in the *Privy-Garden, London*, now gone to Ruin, was antiently the finest in the World.
- 321 *Sutton's or Collins's Quadrants*.
- 322 *Gunter's Quadrants, &c.*
- 323 Two *Hemispheres*, projected on the Plane of the *Ecliptick*, containing all the Stars in Mr. *Flamsteed's Catalogue*.
- 324 Two *Hemispheres* on the Plane of the *Equator*, shewing the right Ascension and Declination of the Stars in the same Catalogue.
- 325 The *Zodiack*, containing all the Stars in the Way of the Planets, with Dr. *Halley's* Method for finding the Longitude at Sea.
- 326 *Planispheres*, or Projections of the celestial Sphere, upon the several Planes, viz. that of *Ptolemy*, where the Plane of the Projection is parallel to the *Equator*; that of *Gemma Frisius*, where the Plane of Projection is the *Colure*, or solstitial Meridian; that of *John de Royas*, or *Annelemma*, whose Plane of Projection is a Meridian, and Place of the Eye in the Axis of that Meridian, at an infinite Distance; that of M. *de la Hire*, the Plane of which Projection is also a Meridian, and Place of the Eye in that Point where the Divisions of the Circles projected are sensibly equal.
- 327 *Orreries*, or *Planetariums*, of about 12 Inches Diameter, which shew the Motion of the Earth and Moon about the Sun.
Orreries, about two Foot Diameter, which shew the Motion of the Earth and Moon together, with the Inclination of the Moon's Orbit, the Retrogradation of the Nodes. The annual and diurnal Motions of the Earth, and Motion of the Sun round his Axis, &c.
- 328 A *Planetarium*, about two Foot Diameter, with all the Motions of the last Number, and the Addition of the two inferior Planets *Mercury* and *Venus*, the former having its annual, and the latter both its annual and diurnal Motions. By this Instrument the Situations of the Planets, with Respect to the Earth at different Times, as they appear direct stationary or retrograde, are plainly visible, as is also the Eclipses of the Sun and Moon, and the Vicinities of the Seasons, &c.
- 329 A *Planetarium*, of two Feet and an half Diameter, with all the Properties of the two foregoing Numbers, and the Addition of the
the

the three superior Planets, *Mars*, *Jupiter*, and *Saturn*, with their annual Motions.

- 330 A *Planetarium* of about three Feet and an half Diameter, handsomely ornamented, containing all the Particulars of the three foregoing Numbers, and the Addition of the diurnal Motions of *Mars*, and *Jupiter*, together with the Motions of all the secondary Planets round their respective Primaries in their proper Periods, &c.

All these Planetary Machines are so constructed, as to render all the Phænomena (they are intended to demonstrate) very easy and intelligible.

- 331 The famous *Glass Sphere* of the Reverend and Learned Dr. *Long's* Invention, which exhibits at one View both the real and apparent Motion of the Heavens.

- 332 The *Uranium* invented by the Reverend Dr. *Long*.

- 333 *Astronomical Clocks*, or Regulators carefully performed.

- 334 A particularly new and curious Machine, containing a Movement which plays either an Organ, or Harpsichord, (or both if desired) in a masterly Manner; shews the exact Time of the Day and Night, and sets a going a transparent Firmament, which exhibits the apparent rising, southing, and setting of the Sun, Moon, and Stars, their right Ascensions, Declinations, Altitudes, and Amplitudes, &c. the Times of their Appearance and Disappearance to an Inhabitant on any Part of the terraqueous Globe, the Place of the Sun and Moon in the Zodiack, and amongst the fixed Stars, whereby the cosmical, heliacal, and achronical Risings and Settings thereof, are easily discover'd, and the natural apparent Face of the Heavens, at all Times of the Day and Night, and that in any particular Part of the World, and many other Observables of the Earth, &c. In short, it is a most beautiful, instructive, and ornamental Piece of Furniture, not unworthy the grandest Apartment in any Gentleman's or Nobleman's House.

- 335 A COSMOTHEORION, or Machine, of a new Invention, which at present is without a Parallel.

It is about four Feet and a half Diameter, standing upon a Pedestal of curious Workmanship.

In its Center the Sun is seen to perform a Revolution about its own Axis in 25 Days, its Axis being at the same Time inclined to the Plane of the Ecliptick, in an Angle of $66\frac{1}{2}$ Degrees. The other Planets, move round it, in which Motion, particular Regard is had both to their proportionable Distances and Eccentricities, as well as to their respective Inclination in the Plane of the Ecliptick. Their proportionable Times and Magnitudes are likewise

wise remarked; (according to the System generally received among Astronomers) and the Planets themselves are surrounded by a transparent Firmament, whereon the several Constellations are delineated, by which Means the Variety of Aspects the Planets appear under to a Spectator in either of them, with Respect to their Motions and Situations amongst the fixed Stars, are plainly seen, sometimes direct, sometimes stationary, and at other Times retrograde. The Earth (on which the principal Kingdoms are described, is accompanied by a natural Horizon, and a representative Inhabitant, which may be set to any Latitude) makes its Revolution in the Plane of the Ecliptick. Besides its diurnal Motion about its Axis, its Axis remaining parallel to that of the World, shews the Causes of Day and Night, and the Mutations of the Seasons. Round this Globe revolves the Moon, in an inclined elliptick Orbit (in one of whose Foci the Earth is placed) the Apfides of which advance and recede every Luration, so as to perform a Motion in Consequentia in its proper Period, whilst the Nodes move round in Antecedentia. The Eccentricity of this elliptick Orbit, is continually changing into a new Curve, and its Latitudes both northern and southern are fully shewn. It also shews the periodical and synodical Month, the several Phases of the Moon, her Age, and Place in the Zodiack, which gives a clear Idea of the Manner in which lunar Eclipses are occasioned, and may be very ingeniously demonstrated. The Tides are also accounted for in a very intelligible Manner, and as the Observations of the Eclipses of *Jupiter's* Satellites is of great Use in Astronomy, a particular Regard hath been had to construct their Motion in inclined Planes, as well as those of the Satellites of *Saturn*; and their Distances, Magnitudes, and true Periods, are also shewn, together with their Immersions into, and Emersions out of the Shadow of their respective Primary. A Celidography of *Venus* is also exhibited.

All the Planetary Bodies are put in Motion at once, and the Movement that sets them a going, is regular, and easy, and capable of being continued for a very considerable Time. In short the Contrivance of the whole Machine is such, that all the Problems of Astronomy, Geography, &c. (the Physicks excepted) may be either explain'd or illustrated by it.

F I N I S.

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